

**LATE PRECONTACT AND PROTOCONTACT STONE CIRCLE SITES
AT LITTLE MANITOU LAKE,
SOUTH-CENTRAL SASKATCHEWAN**

A Thesis Submitted to the College of
Graduate and Postdoctoral Studies
In Partial Fulfillment of the Requirements
For the Degree of Master of Arts
In the Department of Archaeology and Anthropology
University of Saskatchewan
Saskatoon

By

KAY JOLLYMORE

Permission to Use

In presenting this thesis in partial fulfilment of the requirements for a Graduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis.

Requests for permission to copy or to make other use of material in this thesis in whole or part should be addressed to:

Head of the Department of Archaeology and Anthropology
University of Saskatchewan
55 Campus Drive
Saskatoon, Saskatchewan, S7N 5B1
Canada

Abstract

This study focuses on the Little Manitou Lake archaeological complex, a collection of sites situated around the western end of Little Manitou Lake, located in south-central Saskatchewan. The majority of sites documented in this region contain stone circle features suggesting residential/domestic use while a handful of sites have been documented as ceremonial in nature, containing medicine wheels and vision quest features. Today, Little Manitou Lake is hypersaline and has been so for the last 2,000 years. Evidence suggests that the lake was previously a deep freshwater lake. Changing climatic and environmental conditions responsible for the transformation of the lake would likely have influenced lifeways of past populations and may have influenced use of this area. Archaeological sites around Little Manitou Lake have been hypothesized to relate to the saline/healing nature of the water. The named Manitou comes from an Algonquian word meaning “great spirit” and the lake became known as the “Lake of Healing Waters”. Ethnographic information indicates that aboriginal groups made pilgrimages to the lake to experience the lakes healing properties.

The main objective of this research was to improve understanding of interactions between past populations and the environment of the Little Manitou Lake area and to set the local archaeological record into the broader context of Northern Plains prehistory. The importance of this area to past populations is demonstrated by the density of archaeological sites identified around the lake. Considering paleoenvironmental data in relation to these sites provides new insights about human-environment interactions and how changing environmental conditions may have influenced past use of this area. To achieve the objective of this study, three goals were set out and explored: to identify hearth deposits at archaeological sites that could provide dates for site occupation in the area, to review paleoenvironmental data to better understand changing water and salinity levels of the lake through time, and to carry out spatial analyses to evaluate how site placement may relate and help elucidate the overall cultural landscape.

Hearth deposits, containing charred organics, were identified which produced dates for three archaeological sites, establishing part of the cultural chronology for the region and

provided data which suggest occupation occurred during the late summer or early autumn. The sites were found to belong to the Precontact and Protocontact periods. Data from EkNk-3 indicated that occupation occurred during a period of transition from the Late Old Women's phase to the Mortlach phase while data from EkNj-4 and EkNj-68 indicated that occupations occurred during the Mortlach phase. Dates from these sites, when compared to the literature relating to paleoenvironmental conditions in the region, allowed for the inference that Little Manitou Lake was a saline lake during site occupation, leading to an improved understanding of the environmental context in which the sites were utilized.

Spatial analyses were conducted on both domestic and ceremonial sites in the area. Spatial evaluations of domestic sites at the western end of Little Manitou Lake provided insight about the patterning of features present at the sites. Spatial evaluations of ceremonial sites provided insight about the importance of prominent topographic features in the region and helped to elucidate the overall cultural landscape.

Taken as a whole, data collected during this study provides substantive new insights about the archaeological environment at Little Manitou Lake.

Acknowledgements

The success of this research project was made possible by many. I would like to thank the members of my advisory committee for their mentorship, insightful feedback, and suggestions during the course of this project. Thank you to Dr. Margaret Kennedy and Dr. Glenn Stuart who served as co-supervisors and provided exceptional advice, guidance, and direction for the project. Thanks also to Dr. Alec Aitken for assisting with the identification of molluscs recovered from one of my study sites and for constructive comments on numerous aspects of this thesis. I also thank Dr. Chris Foley for providing ideas and feedback for the spatial components of this thesis. And to my external examiner, Dr. James Merriam, thank you for the thought-provoking feedback you brought to the defense and the valuable input you provided.

The field component of this research would not have been possible without support from a number of landowners in the Little Manitou Lake area. Thank you to Allan and Linda Leslie, David Schaan, Larry Teneycke, Richard and Bernice Dengler, and Shirley Deneiko for permission to access archaeological sites. Their interest and support of the project is much appreciated. Thanks also to Dr. Terrance Gibson and Dr. Krista Gilliland of Western Heritage Services Ltd.; Terry for his expertise in carrying out the magnetometry surveys for this project and providing interpretation of the results and Krista for analyzing and interpreting POSL samples and providing guidance and advice for collecting the samples while I was in the field. And of course a huge thank you to the raft of volunteers who toiled in the field with me: Stephen Jollymore, Murray Jollymore, Teresa Wight, Robyn Pollock, Julia Coutts, Verna Gallen, Glenn Stuart, Margaret Kennedy, Laura Shuttleworth, Susan Alcock, and Kathy Bergen.

Thanks to the Archaeological Resource Management Section of the Saskatchewan Heritage Conservation Branch for their assistance with the project, particularly Nathan Friesen and Lorna Dmyterko who fielded many inquiries and data requests and provided data, advice, and guidance. Thanks also to the Archaeological Survey of Alberta and the Montana State Historic Preservation Office for providing comparative data and CRM reports. Thanks to the Royal Saskatchewan Museum for acting as the repository for material collected during this study

and for providing data for sites which were documented before the incarnation of the Heritage Conservation Branch.

This project would not have been possible without the generous financial support of many sponsors. Thanks to the Saskatchewan Heritage Foundation, the Saskatchewan Archaeological Society and Saskatchewan Lotteries Trust Fund for Sport, Culture and Recreation, Esri Canada, Nature Canada and the Charles Labatiuk Endowment Fund, Saskatchewan Association of Professional Archaeologists, and the Williams Lake Royal Canadian Legion. Several funding initiatives were also awarded through the University of Saskatchewan, including the Master's Graduate Scholarship, the History Department Travel Fund, and the Anthropology Trust and Alexander Vitkowski Bursary from the Department of Archaeology and Anthropology. Additional support was provided by my employers, ERM Consultants Canada Ltd., who allowed me time for educational leave to pursue my Master's degree and provided financial support/educational incentives.

Thanks to friends and fellow graduate students for providing feedback, brainstorming, and excellent advice. Thanks also to my colleague Daniel Walker who took time out of his busy schedule to read my chapters and provide excellent advice. And thanks to my mom and dad for fostering my love of old things, supporting me through my undergraduate degree which provided a solid foundation for this thesis, and to my twin sister for all her support and for putting up with my constant talking about old things. Love you family!

Perhaps most importantly, special thanks to my husband and fellow map-making co-conspirator for his unfailing support. Stephen provided love, encouragement, and guidance during my foray back to academics. He agreed to move to Canada's middle east (aka Saskatchewan) from our home in North Vancouver so I could pursue graduate studies at a stellar university, assisted with the many cartographic endeavors illustrated in this thesis, and even came out to dig, providing the backbone of my volunteer staff! This thesis would not have been possible without his unwavering support.

Table of Contents

Permission to Use	i
Abstract	ii
Acknowledgements	iv
Table of Contents	vi
List of Tables	xi
List of Figures	xii
Glossary and Abbreviations	xiv
Chapter 1 Introduction	1
1.1 Research Objectives	4
1.2 Organizational Summary	5
1.3 A Note About Dates and Radiocarbon Dating	6
Chapter 2 Geologic and Paleoenvironmental Setting	8
2.1 Geological Setting	8
2.1.1 Glacial History	8
2.1.2 Geology and Lithostratigraphy of Central Saskatchewan	13
2.1.3 Hydrology	16
2.2 Paleoclimatic and Paleoenvironmental Background	18
2.2.1 Holocene Climate Change in Southern Saskatchewan	19
2.2.1.1 Early Holocene Climatic Conditions	21
2.2.1.2 Middle Holocene Climatic Conditions	22
2.2.1.3. Late Holocene Climatic Conditions	24
2.2.2 Paleolimnology of Little Manitou Lake	25
2.2.2.1. Evaluation of Little Manitou Lake Paleolimnology with Regional Proxy Data	27
2.3 Current Environmental Setting	30

2.3.1 Ecology and Climate.....	30
2.3.2 Regional Hydrology.....	32
2.4 Chapter Summary	33
Chapter 3 Archaeological and Historical Background	35
3.1 Stone Circle Investigations on the Northern Plains	35
3.1.1 Stone Circles on the Northern Plains	35
3.1.1.1 Geographic Extent and Placement	37
3.1.1.2 Attributes of Stone Circles and Associated Deposits	39
3.1.1.3 Temporal and Cultural Associations.....	43
3.1.2 History of Stone Circle Investigations.....	45
3.1.2.1 Early Accounts.....	45
3.1.2.2 Early Studies - 1930s to 1960s.....	46
3.1.2.3 Stone Circle Research Boom Years - 1970s to 2000s	46
3.1.2.4 Current Investigation Strategies and New Research Directions	48
3.2 Regional Archaeology	52
3.2.1 Archaeological Sites Within the Study Area	54
3.3 Regional Historical Background.....	56
3.4 Chapter Summary	58
Chapter 4 Research Methods	60
4.1 Background Review.....	60
4.2 Field Methods	60
4.2.1 Site Selection and Survey	60
4.2.2. Remote Sensing - Magnetometry and Magnetic Susceptibility.....	61
4.2.2.1. Magnetometry	61
4.2.2.2. Magnetic Susceptibility	63
4.2.3 Evaluative Testing	63
4.2.4 Stone Feature Documentation.....	65
4.3 Laboratory Methods.....	66

4.3.1 Artifacts	66
4.3.2 Paleobotanicals	66
4.3.3 Faunal and Shell Remains.....	68
4.3.4 Radiocarbon Dating and Optically-Stimulated Luminescence Analysis.....	68
4.3.4.1 Radiocarbon Dating	68
4.3.4.2 Portable Optically-Stimulated Luminescence.....	68
4.4 Spatial Analyses.....	71
4.5 Site Documentation and Curation.....	71
Chapter 5 Excavation Results	72
5.1 EkNj-4.....	72
5.1.1 Magnetometry, Feature Mapping, and Magnetic Susceptibility.....	72
5.1.2 Excavation Results.....	76
5.1.2.1 Lithic Material	78
5.1.2.2 Faunal Remains.....	80
5.1.2.3 Historic Material	80
5.1.2.4 Paleobotanical Remains	82
5.1.3 Radiocarbon Dates	82
5.1.4 EkNj-4 Summary	83
5.2 EkNj-68.....	84
5.2.1 Magnetometry, Feature Mapping, and Magnetic Susceptibility.....	84
5.2.2 Excavation Results.....	86
5.2.2.1 Lithic Material	89
5.2.2.2 Paleobotanical Remains	90
5.2.3 Radiocarbon Dates	91
5.2.4 EkNj-68 Summary	91
5.3 EkNk-3.....	92
5.3.1 Magnetometry, Feature Mapping, and Magnetic Susceptibility.....	92
5.3.2 Excavation Results.....	95

5.3.2.1 Lithic Material	100
5.3.2.2 Faunal and Shell Remains.....	101
5.3.2.3 Historic Material	102
5.3.2.4 Paleobotanical Remains	103
5.3.3 Radiocarbon Dates	103
5.3.4 EkNk-3 Summary	104
5.4 Chapter Summary	105
Chapter 6 Spatial Analyses	107
6.1 Domestic Site Spatial Analyses	107
6.1.1 Methods	107
6.1.2 EkNj-4 Spatial Analysis.....	110
6.1.3 EkNj-68 Spatial Analysis.....	115
6.1.4 EkNk-3 Spatial Analysis.....	118
6.1.5 Summary	125
6.2 Ceremonial Landscape.....	125
6.2.1 Methods	126
6.2.2 Ceremonial Site Viewsheds	127
6.3 Chapter Summary	135
Chapter 7 Interpretation and Discussion.....	137
7.1 Archaeological Material.....	137
7.1.1 Lithic Materials	137
7.1.2 Faunal and Shell Remains.....	138
7.1.3 Historic Materials.....	139
7.1.4 Paleobotanicals	140
7.1.5 Hearths	146
7.2 Radiocarbon Dates	148
7.3 Site Occupation.....	151
7.3.1 EkNj-4 and EkNj-68 and Mortlach Phase	152

7.3.2 EkNk-3 and Late Old Women's/Mortlach Transition	154
7.4 Spatial Arrangements.....	159
7.4.1 Domestic Sites	159
7.4.2 Ceremonial Sites	162
7.5 Paleoenvironmental Record.....	162
Chapter 8 Conclusions and Future Research Directions.....	167
8.1 Concluding Remarks.....	167
8.2 Areas For Future Research.....	171
8.3 Summary	173
References Cited	174
Appendix A: Magnetometry Results and Mapped Stone Circles.....	206
Appendix B: Artifact Catalogues and Debitage Analysis	219
Appendix C: Soil Stratigraphy	238
Appendix D: Radiocarbon Analysis Results.....	245
Appendix E: Portable Optically Stimulated Luminescence Results.....	257

List of Tables

2.3-1	Seasonal changes and vertical differences in the salinity of Little Manitou Lake, May to September 1940.	33
3.1-1	Stone circle sites dated by radiocarbon analysis on the Northern Plains.....	51
5.1-1	Results of magnetic susceptibility evaluations carried out on matrix samples from EkNj-4.....	75
5.1-2	Summary of artifacts recovered from EkNj-4.	76
5.1-3	Summary of debitage recovered from EkNj-4.....	80
5.1-4	Matrix samples subject to flotation and paleobotanical analysis from EkNj-4.	82
5.1-5	Summary of paleobotanical plant taxa recovered from EkNj-4.	83
5.1-6	Charcoal samples from EkNj-4 subject to AMS radiocarbon analysis.....	83
5.2-1	Results of magnetic susceptibility evaluations carried out on matrix samples from EkNj-68.....	86
5.2-2	Summary of artifacts recovered from EkNj-68.	87
5.2-3	Summary of debitage recovered from EkNj-68.....	90
5.2-4	Matrix samples subject to flotation and paleobotanical analysis from EkNj-68.	91
5.2-5	Summary of paleobotanical plant taxa recovered from EkNj- 68.	91
5.2-6	Charcoal samples from EkNj-68 subject to AMS radiocarbon analysis.....	91
5.3-1	Results of magnetic susceptibility evaluations carried out on matrix samples from EkNk-3.....	95
5.3-2	Summary of artifacts recovered from EkNk-3.....	96
5.3-3	Summary of debitage recovered from EkNk-3.....	101
5.3-4	Matrix samples subject to flotation and paleobotanical analysis from EkNk-3.	103
5.3-5	Summary of paleobotanical plant taxa recovered from EkNk-3.	104
5.3-6	Charcoal samples from EkNk-3 subject to AMS radiocarbon analysis.....	104
6.2-1	Inter-visibility of ceremonial sites at Little Manitou Lake.	127
6.2-2	Distances between ceremonial sites at Little Manitou Lake.....	127
6.2-3	Inter-visibility of ceremonial and domestic sites at Little Manitou Lake.....	135
7.2-1	Stone circle sites on the Northern Plains dated to the late Precontact and Protocontact periods.....	150

List of Figures

1-1	Location of study area.....	2
1-2	Study area.....	3
2.1-1	Subdivisions of the Quaternary used in Canada.	9
2.1-2	Regional proglacial lakes and spillways.	10
2.1-3	Distribution of topographic elements in the Little Manitou Lake area.....	11
2.1-4	Topographic profiles and map of the Watrous spillway and fan.	12
2.1-5	Geological cross-section through the Little Manitou Lake area illustrating preglacial and present topography.....	14
2.1-6	Stratigraphic chart of formations, chronostratigraphy, and lithology of central Saskatchewan.....	15
2.1-7	Aquifer, groundwater, and geological cross-section of the Little Manitou Lake area.	17
2.2-1	Holocene climate change in Southern Saskatchewan: A multi-proxy panorama.	20
2.2-2	Lakes on the Northern Great Plains discussed in this chapter.	22
2.2-3	Schematic of Little Manitou Lake lithostratigraphic profile.	26
3-1	Cultural chronology of the Northern Plains/Southern Saskatchewan.....	36
3.1-1	Tipi with stone weights, illustrating seasonal adjustments to optimize ventilation in summer and heat retention in winter.....	37
3.1-2	Map of the Great Plains cultural region with archaeological subdivisions and sites discussed in this section.	38
3.2-1	Archaeological sites discussed in this section.	55
4.2-1	FM256 Fluxgate Gradiometer and magnetic survey at EkNj-68.....	62
4.2-2	Excavation area naming convention.	64
4.2-3	Recording a stone circle at EkNk-3 using the "tipi-quik" method and a sketch of the tipi-quik apparatus.	65
4.3-1	Model A Flote-Tech machine-assisted flotation system used to process matrix samples and floated matrix samples on drying racks, awaiting analysis.....	67
4.3-2	POSL sample tubes in place through the hearth indentified at EkNk-3	69
5-1	Study area and location of EkNj-4, EkNj-68, and EkNk-3.....	73
5.1-1	View south across southern half of EkNj-4 and toward the Little Manitou Lake valley.	72
5.1-2	Focused area of investigation at EkNj-4.....	74
5.1-3	Mapped rocks of Feature 7, magnetometry results for Grid 2, and area of subsurface excavation at EkNj-4.....	75
5.1-4	Profile of hearth excavated at EkNj-4.....	78
5.1-5	Summary of lithic material types recovered from EkNj-4.....	79
5.1-6	Faunal material recovered during excavations at EkNj-4 and EkNk-3	81
5.1-7	Lead birdshot pellet sizes.....	81
5.1-8	Historic shot pellets recovered during excavations at EkNj-4 and EkNk-3	81
5.2-1	View north toward EkNj-68 and the Little Manitou Lake valley.....	84
5.2-2	Site map of EkNj-68 with area of detailed investigation.....	85

5.2-3	Mapped rocks of Feature 11, magnetometry results for Grid 3, and area of subsurface excavation at EkNj-68.....	86
5.2-4	Profile of hearth excavated at EkNj-68.....	88
5.2-5	Summary of lithic material types recovered from EkNj-68.....	89
5.3-1	View south-southwest toward EkNk-3.	92
5.3-2	Focused area of investigation at EkNk-3.	93
5.3-3	Results of magnetometry Grids 1, 6, and 9 and mapped rocks for EkNk-3 Feature 2 and adjacent areas, column sample from unit B44, and excavation units B75 and B85.	94
5.3-4	Profile of eastern walls of excavation units at EkNk-3 illustrating hearth deposits.	97
5.3-5	Summary of lithic material types recovered from EkNk-3.....	100
5.3-6	Shells of snail species recovered from EkNk-3	102
6.1-1	Results of nearest neighbor analyses for EkNj-4.....	111
6.1-2	Distribution of nearest neighbor distances between stone circles at EkNj-4.....	112
6.1-3	Site map of features at EkNj-4, illustrating buffered proximity analysis.	113
6.1-4	Viewshed from linear arrangement of stone circle features on the western side of EkNj-4.....	114
6.1-5	Ground-truthed viewscape from Feature 7 at EkNj-4.....	115
6.1-6	Results of nearest neighbor analyses for EkNj-68.....	116
6.1-7	Distribution of nearest neighbor distances between stone circles at EkNj-68.....	117
6.1-8	Site map of features at EkNj-68, showing buffered proximity analysis.	117
6.1-9	Viewshed from linear arrangement of stone circle features on the western side of EkNj-68.....	119
6.1-10	Ground-truthed viewscape from Feature 11 at EkNj-68.....	119
6.1-11	Results of nearest neighbor analyses for EkNk-3.....	120
6.1-12	Distribution of nearest neighbor distances between stone circles at EkNk-3.....	122
6.1-13	Site map of features at EkNk-3, showing buffered proximity analysis.	122
6.1-14	Viewshed from linear arrangement of stone circle features at EkNk-3.....	123
6.1-15	Ground-truthed viewscape from Feature 2 at EkNk-3, view east.....	124
6.1-16	Ground-truthed viewscape from Feature 2 at EkNk-3, view south.	124
6.2-1	Results of cumulative viewshed analysis for ceremonial sites at the western end of Little Manitou Lake.	128
6.2-2	The glacial erratic at EkNk-4, looking northeast.	132
6.2-3	Ground-truthed view from EkNj-21, looking northwest	134
7.2-1	Selected stone circle sites on the Northern Plains dated to the late Precontact and Protocontact periods.....	151
7.3-1	Approximate geographic range of the Mortlach phase, ca. AD 1300-1750 and archaeological sites dated to this phase discussed in this chapter.	153
7.3-2	Approximate geographic range of the Old Women's phase, ca. AD 800-1300 and archaeological sites dated to this phase discussed in this chapter.	156
7.5-1	Lakes on the Northern Plains discussed in this chapter.	164

Glossary and Abbreviations

Terminology used in this thesis is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AD	anno Domini - a Latin phrase meaning “in the year of our Lord.” An abbreviation used with dates indicating how many years have passed since the birth of Jesus Christ.
Alluvium	A deposit of clastic, detrital materials transported by a stream or river and deposited as a river floodplain (Allaby 2008).
AMS	Accelerated Mass Spectrometry. A technique that allows for the measurement of atomic and molecular masses (Allaby 2010) and is used in radiocarbon analysis to detect the number of ^{14}C atoms present in a sample (Bowman 1990).
Aquitard	A non water-bearing layer with a very low permeability, enabling flow of water vertically at a low rate, but not at all horizontally, with limited ability to release water. Most heavy textured and compact soil layers act as aquitards (Canarache et al. 2006).
ARMS	Archaeological Resource Management Section (ARMS) of the Heritage Resources Branch of the Saskatchewan Ministry of Tourism, Parks, Culture and Sport. ARMS administers regulatory provisions of the <i>Heritage Property Act</i> concerned protecting and managing archaeological and paleontological heritage. ARMS also maintains a comprehensive provincial inventory of archaeological and paleontological sites.
asl	Above sea level.
BC	Before Christ. An abbreviation used refer to dates of events that took place before the birth of Jesus Christ.
Borden System	A naming convention used to designate archaeological sites in Canada. The system utilizes a code of four letters (which define an area 10 minutes longitude by ten minutes latitude) and a number which denotes the order in which the site was discovered in a given Borden Block (e.g., EfNj-1) (Archaeological Resource Management Section 2013).
BP	Before present. A term commonly used by quaternary geologists and archaeologists with reference to radiocarbon ages and other radiometric dating techniques. Generally, BP is recorded in relation to the calendar year 1950 AD.
ca	Circa. Meaning approximately, often in reference to a date.

CaSO₄	Calcium sulfate.
Cairn	A type of archaeological stone feature commonly found in this region of Saskatchewan. A cairn is, in essence, an intentionally-laid pile of rocks, carefully stacked without mortar. Cairns are often thought to have some meaning associated with them, such as a landmark, a territorial marker, or a grave marker.
Chernozem	A group of zonal soils developed in a temperate to cool subhumid climate and having a deep, dark to nearly black, highly organic surface horizon grading into a lighter-coloured horizon over an accumulation of lime; normally occurs in subhumid climates under vegetation of medium to tall grass (Morris 1992).
Clast	All of the size groups of primary soil particles with a diameter or length of >2 mm. They are generally differentiated according to size and sometimes also according to shape (Canarache et al. 2006).
DBD	Depth below datum.
DBS	Depth below surface.
Debitage	The waste by-products of stone tool manufacture and maintenance.
DEM	Digital Elevation Model. A digital representation of terrain created from elevation data.
Drift	Any superficial transported material such as till, outwash gravel and sand, and alluvium. Many soils of temperate areas are developed on such materials (Canarache et al. 2006).
Ecotone	A narrow and fairly sharply defined transition zone between two or more different communities (Allaby 2010).
Ephemeral	A waterbody that only exists for short periods of time typically following a precipitation event or snowmelt.
Erratic	A rock carried by a glacier and deposited at some distance from the outcrop from which it was derived (Canarache et al. 2006).
Esker	A long, narrow and sinuous ridge consisting of cross-bedded sand and gravel. Eskers have been laid down by glacial melt water, either at the retreating edge of an ice-sheet or in a subglacial tunnel at the base of the ice (Canarache et al. 2006).
Evaluative Unit	A defined area of excavation, typically square but can vary in size depending on the needs of the research. Each evaluative unit (also termed excavation unit) is used as a controlled area for the recovery and documentation of cultural materials and the study of the stratigraphic soil profiles at an archaeological site.

Facies	Sum total of features/characteristics that reflect the specific environmental conditions under which a given rock or sedimentary unit was formed or deposited. In sedimentary facies, mineral composition, sedimentary structures, and bedding characteristics are all diagnostic of a specific lithofacies (Allaby 2008).
Feature	Portions of an archaeological site which are not portable but have been created or modified by humans (<i>i.e.</i> , stone circles, graves, cairns, historical structures).
Finely disseminated organic matter	Physically small organic material which is dispersed throughout the matrix of a soil horizon (Canarache et al. 2006).
Fluvio-glacial	Relating to or denoting erosion or deposition caused by flowing meltwater from glaciers or ice sheets.
g	Grams.
GIS	Geographic Information System. A system designed to capture, store, manipulate, analyze, manage, and present types of spatial and/or geographical data.
Glacial Erratic	A glacial erratic is a boulder or large stone transported and deposited by a glacier having a different origin than the bedrock upon which it is sitting. Erratics are useful indicators of patterns of former ice flow.
GPS	Global Positioning System. A system that provides locational inform anywhere on earth where there is an unobstructed line of sight to four or more GPS satellites.
Glaciolacustrine	A glacial drift deposit consisting of materials derived from glaciers, reworked and laid down in glacial lakes, often stratified or laminated. The particle-size of these deposits and of soils developed on them ranges from fine clayey to sandy (Canarache et al. 2006).
Historic	Referring to the period after the advent of written historical records in a given geographical region.
<i>Heritage Property Act</i>	Provincial legislation for the protection and management of heritage and archaeological sites in Saskatchewan.
HRIA	Heritage Resource Impact Assessment.
Hypersaline	Salinity which exceeds that of seawater.
Hummocky	Terrain which contains non-linear rises and hollows with many slopes steeper than 15° (25%).
Hyposaline	Salinity which is less than that of seawater.

Lacustrine	Of, relating to, formed in, living in, or growing in lakes.
LiDAR	Light Detection and Ranging. A remote sensing method used to examine the surface of the earth.
Lithic(s)	Stone tools and debitage resulting from the production of stone tools.
Lithostratigraphy	A branch of stratigraphy concerned with the description of rock units in terms of their lithological features. It deals with the spatial relations of such rock units, but does not take into consideration (<i>a</i>) the evolution of the organisms contained within the units (biostratigraphy), or (<i>b</i>) geologic time (chronostratigraphy) (Allaby 2008).
Mg/Ca	Magnesium-Calcium ratio.
Medicine Wheel	An feature found throughout the Northern Plains characterized by a central stone cairn, a stone circle, and/or concentric stone circles with radiating spokes. Often associated with ceremonial activities.
Meromictic Lake	A stratified lake that does not undergo complete mixing of its water during periods of circulation, especially a lake in which the non-circulating bottom layer does not mix with the circulating upper layer (Morris 1992). This is often associated of differential salinity levels within alkaline lakes.
Mesophytic	A plant that flourishes in an environment with moderate amounts of moisture (Morris 1992).
Moraine	A specific landform developed from material carried and deposited by glaciers (Canarache et al. 2006).
nT	Nanoteslas. A unit of measurement which measures the magnitude of the earth's magnetic field (Bevan and Smekalova 2013).
NTS Map	National Topographic System map. A topographic system used in Canada, providing general purpose maps of the country. These maps provide details on landforms and terrain, lakes and rivers, forested areas, administrative zones, populated areas, roads and railways, and other man-made features.
OSL and POSL	Optically stimulated luminescence. A method used to measuring doses of ionizing radiation. For some disciplines (geology, archaeology) it is used to determine how long ago mineral grains were last exposed to sunlight or heating. A portable system for measuring doses was developed to collect readings in the field (Sanderson and Murphy 2010).

Perennial	A waterbody that retains water in its basin throughout the year and is not typically subject to extreme water-level fluctuations.
Pimple mound	Roughly circular or elliptical domes or shield-like mounds often with flat tops, composed of unstratified sandy loam soil coarser than, and distinct from, the surrounding less coarse, often more clayey soil. Basal diameter of pimple mounds range from 1 m to more than 30 m with heights from 10 cm to more than 2 m (Johnson and Horwath Burnham 2012).
Playa	Shallow water-filled depressions or basins in landscapes of internal drainage. No external outlet for discharge of water. Water is lost from these basins by evaporation and is associated with the deposition of soluble salts.
ppm	Parts per million.
ppt	Parts per thousand.
Precontact Site	An archaeological site dating to the period before literary, historical, archival, or recorded oral documentation for the period of use or the material culture it contains.
Proglacial Lake	A lake formed either by the damming action of a moraine or ice dam during the retreat of a melting glacier or meltwater trapped against an ice sheet.
RBS	River Basin Surveys. A large scale program of archaeological surveys which were carried out in the 1940s along the Missouri River drainage as a result of the issuance of the <i>Flood Control Act of 1944</i> (Jennings 1985).
RSM	Royal Saskatchewan Museum.
Salinity	The weight ratio of dissolved salts and water.
SAR	Sodium Adsorption Ratio. A measure commonly used as an index of the suitability of water for use in agricultural irrigation, as determined by the concentrations of solids dissolved in the water, typically the ratio of sodium to calcium and magnesium (Lesch and Suarez 2009).
SARR	Saskatchewan Archaeological Resource Record. A form used to document and report all newly discovered archaeological sites in the province of Saskatchewan. SARR Update forms are used to provide new information for previously recorded sites which have been revisited. These forms and associated data (e.g., topographic locational maps, site maps, artifact catalogues), contain the primary details for archaeological sites documented in the Provincial Inventory of Archaeological Sites (Archaeological Resource Management Section 2013).

SAS	Saskatchewan Archaeological Society. A voluntary avocational archaeological organization which promotes public education and research and avocation for conservation of archaeological sites throughout the province of Saskatchewan.
SI	A system of units used to express magnetic susceptibility where mass susceptibility is equal to the volume susceptibility divided by density and is units of cubic meters per kilogram. SI is abbreviate from the French <i>Le Système International d'Unités</i> , (International System of Units) (Dalan 2006).
SK	Saskatchewan.
Slickenside	In soils, the natural crack surfaces produced by swelling and shrinkage in clayey soils that are high in swelling (Allaby 2008).
SSEWSS	Saskatoon Southeast Water Supply System. A system of canals, reservoirs, and pipelines that deliver water from Lake Diefenbaker east to Lanigan, SK.
SSN	“Site of a Special Nature”. A designation given to archaeological sites in Saskatchewan with special or unique characteristics which are afforded special protection under the <i>Heritage Property Act</i> (1980). Many SSNs are some of Saskatchewan's most outstanding archaeological monuments.
Stone Alignment	A type of archaeological stone feature commonly found in this region of Saskatchewan. Stone alignments are often straight lines formed by a series of stones.
Stone Circle	A type of archaeological stone feature commonly found in this region of Saskatchewan. Most stone circles are suggested to be tent rings, the stones used to hold down the fabric of a circular tent made of hide. Smaller stone circles have been suggested to have been used for drying hides or used for temporary shelter.
UAV	Unmanned aerial vehicle. Commonly referred to as drones.
Vertic Horizon	A soil horizon comprised of more than 30% clay, that swells significantly when wet and shrinks when dry, and that exhibits slickensides (Allaby 2008).
WAAS	Wide Area Augmentation System. A US Federal Aviation Administration funded service which improves the overall integrity of the GPS signal for users in North America (Garmin 2006). Using satellites and ground reference station positions across the United States that monitor GPS satellite data, a corrected GPS signal can be produced. The WAAS corrected signal is broadcast via the WAAS GEO satellites to users in the service area.

It became known as the "Lake of Healing Waters"...

Ruth Schellenberg 1996:7

Chapter 1

Introduction

The idea behind this thesis first took shape while walking and surveying the hills surrounding Little Manitou Lake. The lake itself seemed to be an important feature within the landscape, with its salty waters forming a small inland sea within a deeply incised valley. But it was the large number of stone circle sites that we recorded around the lake that really spurred my interest. When had these sites been used and why had people come to this place? Finding the answers to these questions forms the foundation of this thesis.

The research focuses on the Little Manitou Lake archaeological complex, a collection of sites situated around the western end of Little Manitou Lake. The lake is located east of the village of Young, Saskatchewan (SK), approximately 75 km southeast of the city of Saskatoon, SK (Figure 1-1). The study area measures 16 km east-west by 11 km north-south (Figure 1-2), taking in the western half on Little Manitou Lake and parts of 1:50,000 National Topographic System (NTS) mapsheets 72P/12 and 72P/13, within the Rural Municipalities of Viscount (RM 341) and Morris (RM 312).

Recent archaeological surveys have helped to document hundreds of archaeological sites in this previously poorly understood area (with the notable exception of work carried out around EkNk-4; see Chapter 3), leading to the suggestion that the area was used extensively in precontact times. Thus archaeological investigation within the area has the ability to substantially expand our understanding of the cultural history of the Northern Plains.

The physical characteristics of the region likely contributed to the precontact importance of this place. Today, Little Manitou Lake, a closed-basin lake which lies in a glacial spillway, is a hypersaline lake and has been so for the last 2,000 years BP (Sack and Last 1994). Previously,

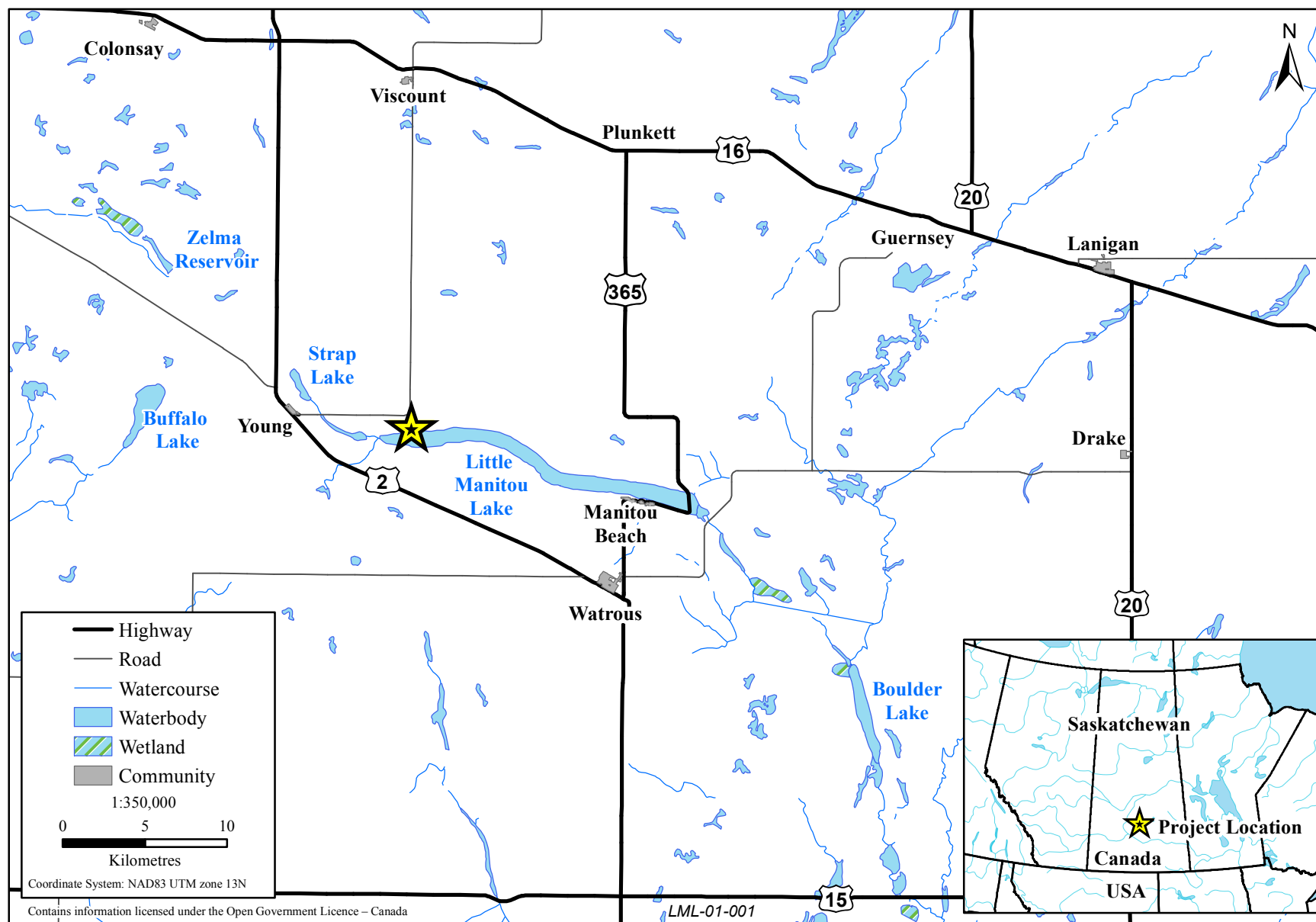


Figure 1-1 Location of study area.

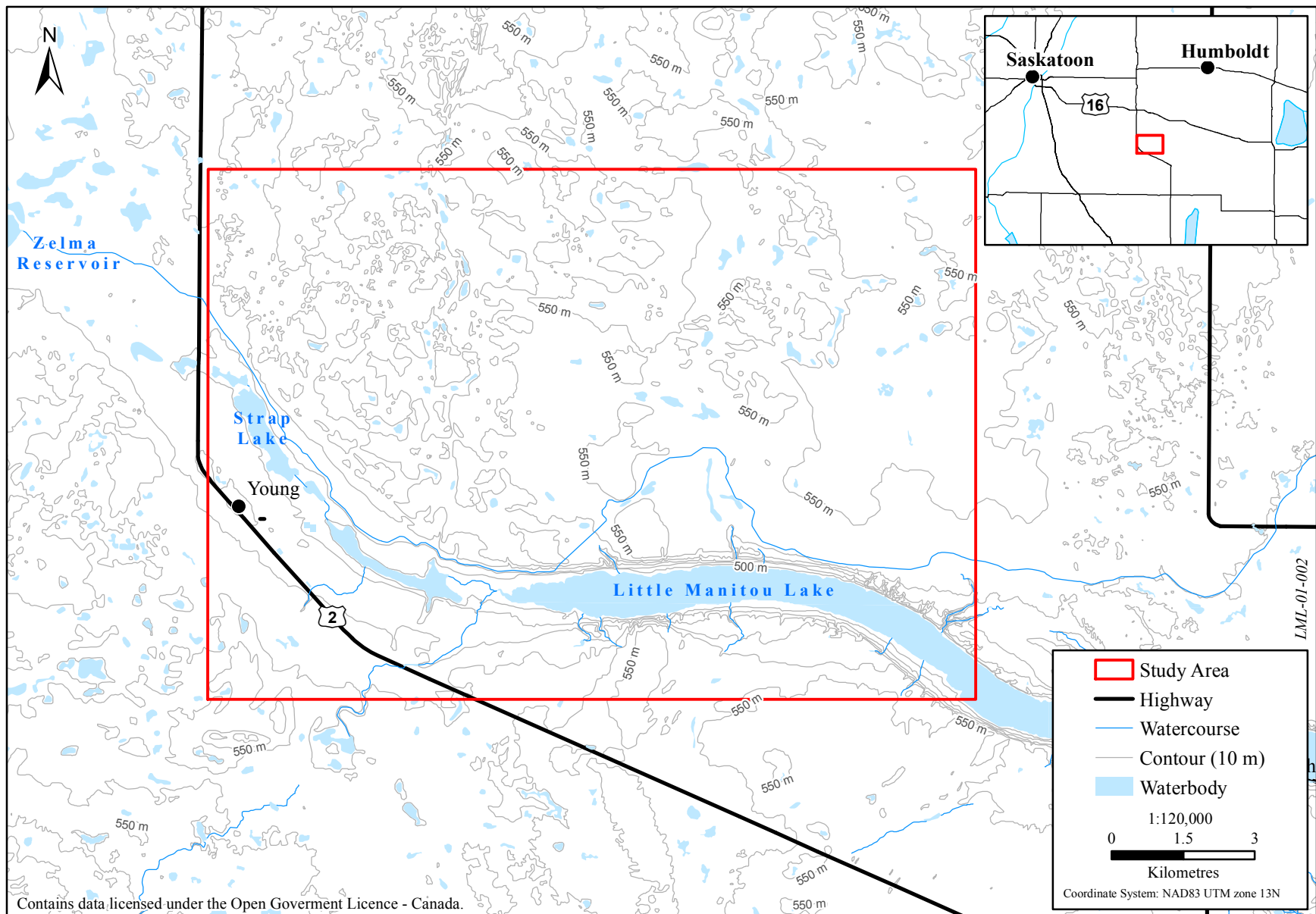


Figure 1-2 Study area.

the lake is suggested to have been a deep freshwater lake. Changing climatic and environmental conditions responsible for the transformation of the lake would also have influenced lifeways of past cultural groups living on the Northern Plains. The lithostratigraphic record of Little Manitou Lake and its position adjacent to the Little Manitou Lake archaeological complex, provides information regarding the climate and environment which were once present. Through an examination of the changing environmental conditions in combination with data from the archaeological record, an attempt can be made to understand when this landscape was used and how it may have been perceived in precontact times.

1.1 Research Objectives

The main objective of this thesis is to improve understanding of interactions between past human populations and the environment of the Little Manitou Lake area and to set the local archaeological record into the broader context of Northern Plains prehistory. The number of sites identified around Little Manitou Lake demonstrates the importance of this area to past cultural groups. Considering paleoenvironmental data in relation to these sites provides new insights about human-environment interactions and how changing environmental conditions may have influenced past use of the area.

As such, this thesis pairs paleoenvironmental information with archaeological data to aid in our understanding and interpretation of site occupation and past land use. To achieve this objective, the following goals were set and methods of inquiry undertaken:

- (1) To place the archaeological sites at Little Manitou Lake more precisely within a regional chronology, subsurface testing was undertaken to locate hearths as the best opportunity to obtain datable material and data that assist in ascertaining specific activities that were carried out at the sites.
- (2) To better understand how paleoenvironmental changes may have influenced the use of this area, paleoenvironmental data for Little Manitou Lake was reviewed to investigate changing water and salinity levels of the lake through time. In addition, paleoenvironmental data for other lakes in the region were examined to provide a broader context for environmental change.
- (3) To elucidate the overall cultural landscape and to evaluate how site placement may relate to the larger landscape, spatial distribution of archaeological site placement was explored. While many of the documented sites in the region suggest residential/domestic use, a handful of sites

have been documented as ceremonial in nature. Therefore, the spatial distribution between ceremonial sites and other site types within the cultural landscape help to provide a deeper understanding of how sites are related and how the landscape may have been used and perceived. In addition, the spatial distribution of site features was explored in an attempt to evaluate the potential for continuous/repeated or single use occupation events, and other spatial patterns.

Original archaeological research described within this thesis was conducted under the auspices of the Archaeological Resource Management Section (ARMS) of the Heritage Conservation Branch, Saskatchewan Ministry of Parks, Culture and Sport, under permit HRIA-Type A 2015-063, held by the author.

1.2 Organizational Summary

This thesis is composed of eight chapters, including this introduction; a brief summary of chapter content is provided here. In addition, appendices containing data and the results of various analyses can be found at the end of the thesis.

Chapter 2 provides background information pertaining to the glacial history, geology, hydrology, and paleoenvironment of the study area. This chapter concludes with a summary of the current climate and ecology of the Little Manitou Lake area.

Given the central role stone circle sites play in this research, Chapter 3 provides an overview of stone circle characteristics and past stone circle investigations on the Northern Plains. A summary of the regional archaeological setting, as currently documented, is also provided. In addition, historic land use which has influenced recent and modern development of the region is briefly summarized.

Chapter 4 outlines the field and laboratory methods used in this study, carried out under research permit HRIA-Type A 2015-063.

Chapters 5 and 6 present the main results of this thesis. Chapter 5 outlines the results of magnetometry surveys and magnetic susceptibility analyses, as well as the results of archaeological excavations and the analyses of lithics, paleobotanicals, faunal, and historic material. In addition radiocarbon dates and portable optically-stimulated luminescence (OSL) data for the sites are presented. Chapter 6 outlines the results of spatial analyses. These chapters are supplemented by additional information presented in the thesis appendices.

Chapter 7 presents the interpretation and discussion of the results presented in Chapters 5 and 6. This includes an evaluation of archaeological materials recovered, site occupation, spatial analyses, and paleoenvironmental data as it pertains to site occupation.

Chapter 8 provides a summary of the thesis research and conclusions regarding the research objectives. It also outlines areas for future research which would complement the findings of the current study, improve upon existing approaches to the study of stone circle sites, and add to understanding of the archaeological environment for the Little Manitou Lake area.

1.3 A Note About Dates and Radiocarbon Dating

Since its inception in the late 1940s, radiocarbon dating has played a major role in establishing chronologies for archaeological sites in the absence of written records, in particular, for late Pleistocene- and Holocene-age precontact materials (Johnson 1955; Taylor 2000). The preferred samples for dating archaeological deposits are organic materials produced during a single season of growth such as seeds, grasses, and small twigs (also referred to as macrofossils or paleobotanicals) (Bowman 1990; Holliday 2004). The process involves the analysis of carbon which has three naturally occurring isotopes: ^{12}C and ^{13}C which are stable and ^{14}C which is unstable and therefore radioactive (Bowman 1990; Taylor 1987). They do not occur equally: carbon consists of about 99% ^{12}C , 1% ^{13}C , and approximately one part in a million ^{14}C (Bowman 1990; Lowe and Walker 2015). All three isotopes combine with oxygen to form carbon dioxide which is mixed throughout the atmosphere where it is taken up by all plant and animal life; carbon dioxide that contains ^{14}C atoms is chemically indistinguishable from that containing ^{12}C or ^{13}C . Once an organism dies, it ceases taking up carbon isotopes at which point ^{14}C begins to decay at a known rate: radioactive decay. The process of establishing radiocarbon dates measures the amount of radioactive ^{14}C remaining in a sample, which produces an uncalibrated radiocarbon date. Calibration can then be carried out to establish a calendar date for the death of the sample material based on known fluctuations in carbon isotope proportions in the atmosphere in the past. Calibrated radiocarbon dates can represent dates BC (Before Christ), AD (anno Domini), or BP (Before Present - calendar year AD 1950). However, in order to be unambiguous when citing dates, the annotation cal BC (e.g., calibrated BC), cal AD, or cal BP should be used to distinguish between calibrated and uncalibrated dates, although a review of archaeological literature indicates that this convention is not consistently used.

Throughout the many studies reviewed for this thesis, it was observed that dates were expressed in a variety of ways; not all studies clearly define the convention used. Wherever possible, attempts have been made to represent dates as uncalibrated radiocarbon dates, annotated as "years BP". Other published conventions have also been used when necessary. In addition, given the relatively recent nature of site occupation for the study sites, archaeological materials which were subject to radiocarbon dating for this study were calibrated (years AD) using standard methods by the A.E. Lalonde AMS Laboratory at the University of Ottawa that produced the dates (for further information see Section 4.3.4, Chapter 5, and Appendix D).

Chapter 2

Geologic and Paleoenvironmental Setting

This chapter sets out information about the physical characteristics of the Little Manitou Lake region. It summarizes the deglaciation of the area as currently documented, describes changes that occurred to the landscape following deglaciation, provides information regarding paleoenvironmental trends, and summarizes current environmental conditions. Understanding these factors is pertinent to understanding the intimate relationship between past populations and the landscape.

2.1 Geological Setting

This section outlines the glacial history for the area, provides a summary of the geology and lithostratigraphy underlying the study area and describes the area's hydrologic conditions.

2.1.1 Glacial History

The most recent glacial event which took place during the Wisconsin glacial period (26,000 to 14,000 years BP; Figure 2.1-1) was associated with the Laurentide Ice Sheet which produced many of the current topographic characteristics of Saskatchewan (Christiansen 1979). This ice sheet was centred on the Canadian Shield and covered much of the province.

This period of glaciation was followed by the Holocene epoch (Figure 2.1-1), which marked the retreat of the last continental glaciers, beginning approximately 15,000 years BP in the southwest and terminating by approximately 8,500 years BP in the northeast (Christiansen 1979). Pillans and Gibbard (2012) state that although the Holocene had generally been thought to have begun 10,000 years BP, more recent research has pushed its start back to 11,700 years BP. It is the Holocene epoch that continues today.

With the retreat of the Laurentide Ice Sheet to the northeast, proglacial lakes began to form, pooling in isolated basins along the ice sheet's southern margins (Christiansen 1979). These lakes, which were impounded by the ice margin and areas of elevated topography,

Tertiary	Quaternary															
Pliocene	Pleistocene													Holocene		
	Early	Middle					Late									
	?					Illinoian		Sangamonian		Wisconsinan				Stage		
								Early		Middle		Late		Sub-Stage		
		15 - - - 9 8 7 6					5		4		3	2		1	Oxygen Isotope Stage	
	1650	700						130	80		65		32	23	13	10

Figure 2.1-1. Subdivisions of the Quaternary used in Canada (after Fulton 1989:3).

released water to the south and east through spillways that formed along glacial margins (Kehew and Teller 1994). As melting progressed and the proglacial lakes grew, outburst floods broke through glacial moraine releasing torrents of melt water that incised deep spillways before draining into other proglacial lakes. Within the region around the study area, three proglacial lakes of note formed: Lake Saskatchewan, Lake Elstow, and Last Mountain Lake (Figure 2.1-2). Initially, Lake Saskatchewan occupied the South Saskatchewan lowland west of the Hawarden and Allan hills. Lake Elstow formed later between the ice margin and the northern end of the Allan Hills. Proglacial Last Mountain Lake occupied the basin within which the present-day, and smaller, Last Mountain Lake lies.

Lake Elstow is of particular interest for this study as it ultimately helped to shape the local topography. Located in a lowland in the Elstow district to the west of the study area, it is thought to have been contained by ice-marginal dams on its west and east and the elevated topography of the Allan Hills to the south (Figure 2.1-2) (Edmunds 1962). Lake levels were affected by three drainage channels: the Lewis and Watrous spillways on the east, and the Blackstrap Coulee/Spillway on the southwest. Former water levels of Lake Elstow have been inferred from lacustrine sediment: elevations of the outlets are thought to have been between 518 and 563 m above sea level (asl) (Greer and Christiansen 1963).

The Lewis Spillway, which lies approximately 5 km west of the village of Simpson, served as an outlet for Lake Elstow when the lake stood between 548 m to 563 m asl. This spillway trends south and formed in a side-hill position between the Allan Hills to the west and the glacier to the east. It is approximately 30 m deep and 610 m wide (Figures 2.1-2 and 2.1-3)

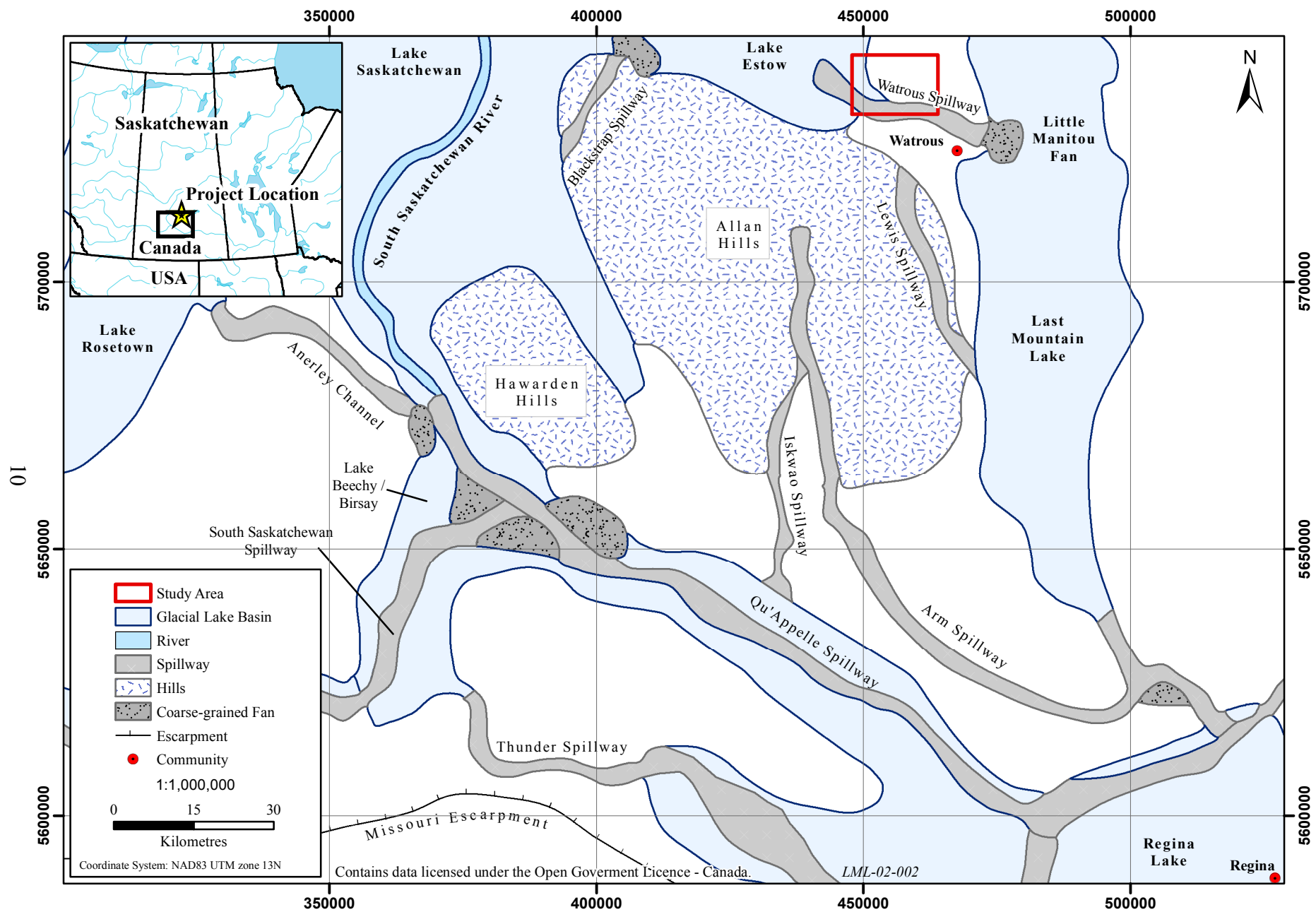
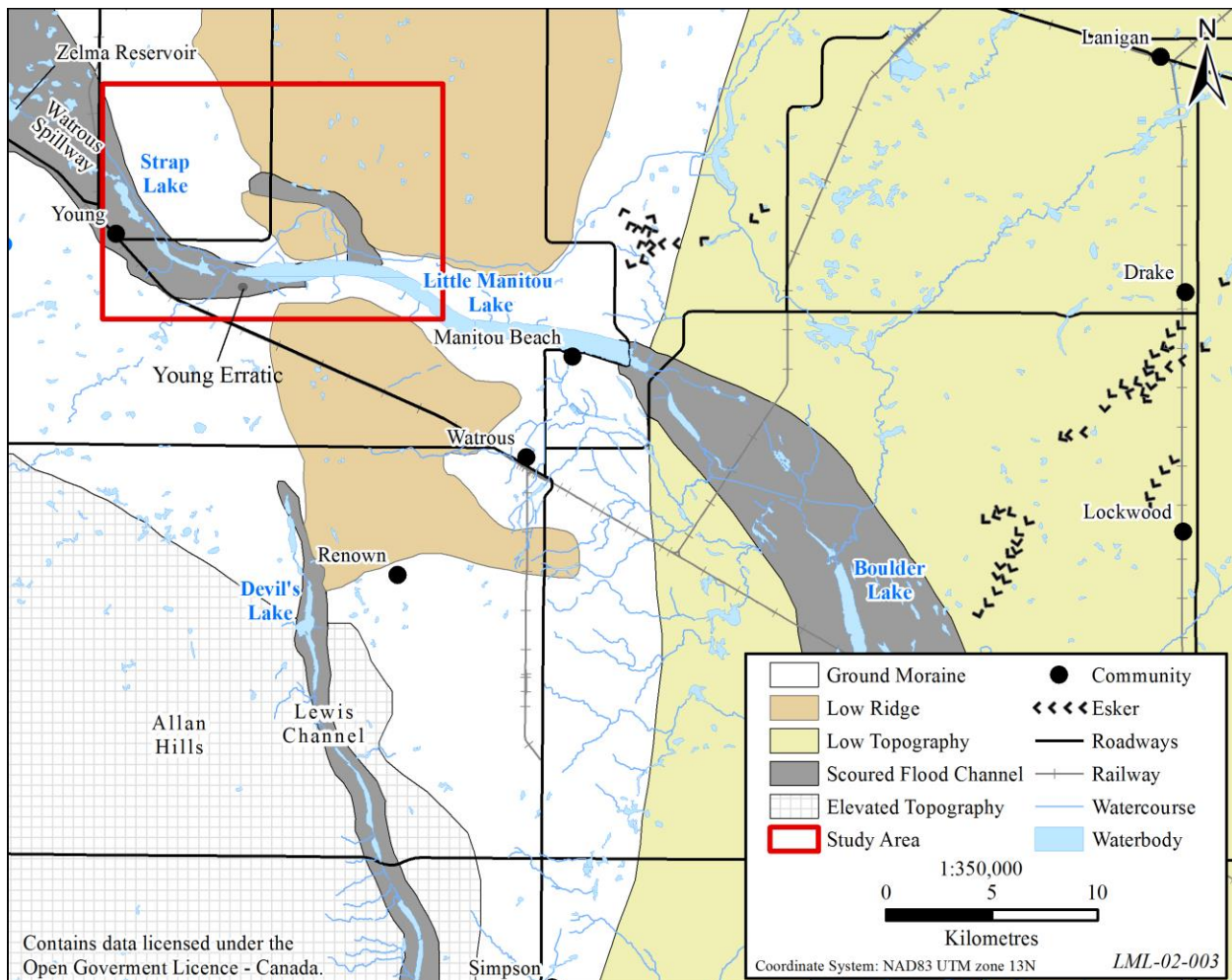


Figure 2.1-2 Regional proglacial lakes and spillways (after Kehew and Teller 1994:545)

(Greer and Christiansen 1963). This spillway is now occupied by Devil's Lake at its northern end and Lewis Creek to the south. Today, Lewis Creek drains into the Last Mountain Lake basin (McDougall 2000).



The Watrous Spillway has been described as complex and differs from other spillways in the region (Greer and Christiansen 1963; Kehew and Teller 1994). It is less than 50 km in length, shorter than most spillways that formed along the southern margins of the Laurentide Ice Sheet, beginning northwest of the Zelma Reservoir and extending east to the Little Manitou fan (Figures 2.1-3 and 2.1-4). Along its length the channel topography "changes from a broad, irregular trough with indistinct sides...to a narrow, deeper trench with very well-defined, uniform side slopes" (Kehew and Teller 1994:546; Figure 2.1-4). Little Manitou Lake now lies within this spillway.

Kehew and Teller (1994) postulate that the spillway was formed in two stages. The initial outflow from Lake Elstow may have moved east along a broad, shallow channel and then southeast through several channels which lie between 525 and 535 m asl above the modern town of Manitou Beach. Water in these channels would have drained toward Last Mountain Lake. The second drainage event released an outburst flood that incised the trench-like channel that we see today to an elevation below 493 m asl (approximately 30 m deep). The outburst flood deposited a thick layer of gravels and boulders which created the Little Manitou fan at the mouth of the spillway (Figure 2.1-3 and 2.1-4). This outburst flood is thought to have occurred approximately 10,000 years BP (Christiansen 1979; Sack and Last 1994). Evaluation of the clast size of the material deposited in the well-developed fan at the mouth of the spillway supports the supposition of a glacial outburst event of an impressive magnitude (Kehew and Teller 1994).

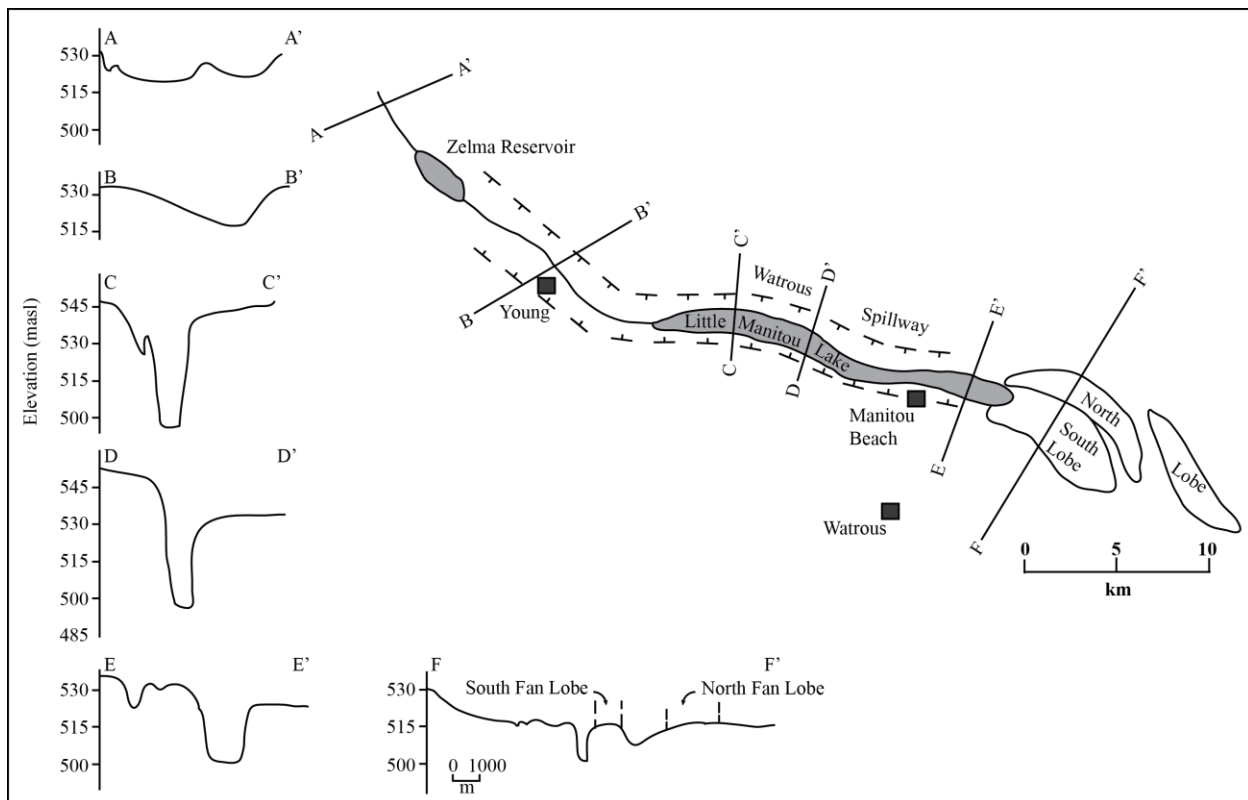


Figure 2.1-4. Topographic profiles and map of the Watrous spillway and fan (after Kehew and Teller 1994:546).

At the upstream end of the spillway is an area of low hummocky relief (5 - 15 m). This area was flooded by stagnant ice that melted after the outburst flood, producing the hummocky topography that is present today (Kehew and Teller 1994). The area between Little Manitou Lake and Boulder Lake (~13 km to the southeast, Figure 2.1-3) contains moraine features that

formed during a period of minor glacial re-advancement, that restricted the Little Manitou Lake basin and created the closed system we see today (Greer and Christiansen 1963).

2.1.2 Geology and Lithostratigraphy of Central Saskatchewan

Bedrock across the Canadian plains is primarily of Cretaceous age, typically consisting of shales and siltstones, laid down in shallow seas (Klassen 1989). This bedrock was largely shaped by pre-Wisconsinan glacial erosion and deposition related to glacial advances and retreats during the Quaternary, creating a complex stratigraphic sequence across the Northern Plains (Fenton et al. 1994).

The bedrock geology underlying the study area is illustrated in Figures 2.1-5 and 2.1-6 and briefly described here. Figure 2.1-5 also illustrates the results of several significant geologic events discussed further below: preglacial erosion, glacial and fluvio-glacial erosion, subsurface collapse and postglacial deposition.

The Bearpaw Formation, a late-Cretaceous geological formation which forms much of the bedrock surface in central Saskatchewan, lies immediately below glacial drift/till (discussed further below). In the study area this formation is composed of soft, gray, non-calcareous marine silt and clay and can be up to 150 m thick (Greer and Christiansen 1963; Simpson 2000).

Pre-Wisconsinan erosion throughout the province resulted from the scouring of drainage systems which flowed from the Rocky Mountains region eastward. These drainage systems were also responsible for the deposition of sediments into the valleys that had been eroded into the bedrock surface. One such valley that trends northwest-southeast across southern Saskatchewan lies to the east of the study area, the Hatfield Valley, an aquifer that serves as a primary source of groundwater for many communities in the region. A small preglacial valley that underlies the study area, illustrated in Figure 2.1-5, is thought to be a tributary of the Hatfield Valley (Greer and Christiansen 1963; McDougall 2000; Simpson 2000). Glacial erosion and subsequent melt-water events, such as the outburst flood that formed the Watrous Spillway, further modified the topography in the region.

The underlying geology in the study area was further modified by collapse events. Subsurface leaching and removal of salt by groundwater resulted in the collapse of overlying

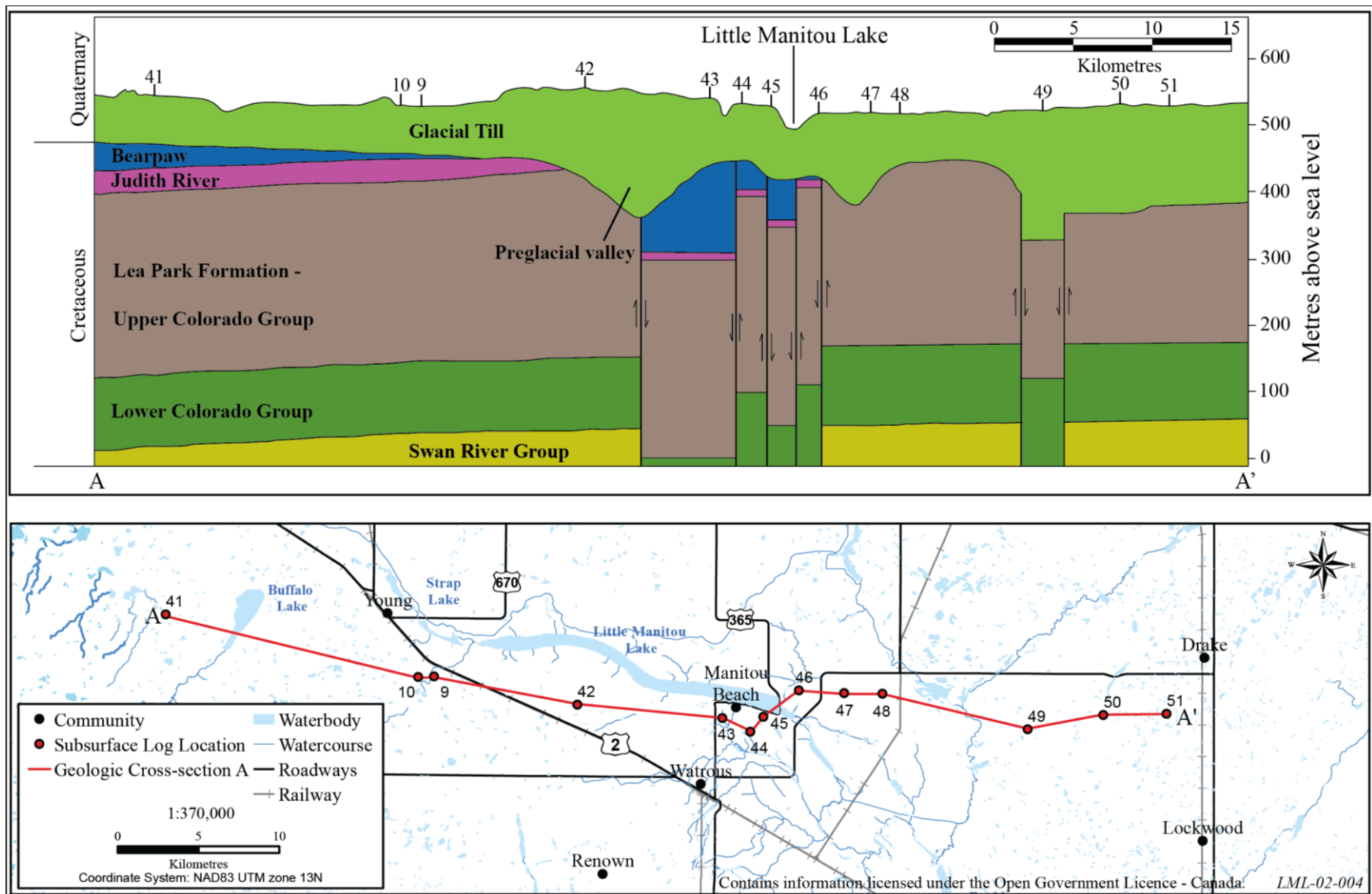


Figure 2.1-5. Geological cross-section through the Little Manitou Lake area illustrating preglacial and present topography (after Christiansen 1970 and McDougall 2000:Figure 1).

Period	Stratigraphy			Lithology	
Quaternary	Surficial Stratified Deposits			sand and silt silt and sand	
	Saskatoon Group	Battleford Formation		till	
		Floral Formation	Upper Floral Till		till
			Riddell Member		sand and gravel
			Lower Floral Till		till
	Sutherland Group	Warman Formation		sand and gravel	
		Dundurn Formation		till	
		Mennon Formation		sand and gravel	
				till	
	Tertiary	Empress Group			sand and gravel
Cretaceous	Pierre Shale	Bearpaw Formation		clay and silt	
		Judith River Formation		sand and silt	
		Lea Park Formation & Upper Colorado Group		clay and silt	
	----- <i>Base of Second White Speckled Shale</i> -----				
Lower Colorado Group			silt and clay		

Figure 2.1-6. Stratigraphic chart of formations, chronostratigraphy, and lithology of central Saskatchewan (modified from Christiansen 1992:1175, Maathuis and Schreiner 1982:Figure 4, and Simpson 2000:6).

strata, a phenomenon which has occurred in many parts of Saskatchewan (De Mille et al. 1964; McLean 1971; Simpson 2000). The most extensive salt deposit in Saskatchewan, the Prairie Evaporite Formation, was deposited as part of a sedimentary shelf bordering on the Canadian Shield during the Middle Devonian (ca. 385 million years ago), reaching a maximum thickness of approximately 200 m and containing extensive potash deposits (Holter 1969). Major salt removal, as a result of large-scale subsurface leaching, has been postulated to have occurred

from the Late Devonian to present, resulting in the collapse of geologic units above the leached salt deposits (Figure 2.1-5).

Glacial deposition in this region resulted in drifts consisting of unsorted sand, silt, clay, pebbles, and boulders as well as glaciolacustrine deposition of sand, silt and clay (Simpson 2000). Glacial till and glaciofluvial sediments dominate the surficial geology of the study area with deposits ranging from 60 to 210 m in thickness (Figure 2.1-5) (Christiansen 1970; Greer and Christiansen 1963; McDougall 2000). The Allan Hills, an area of topographic relief which rises up to 110 m above the surrounding landscape to the southwest of the study area, are primarily the result of the extensive deposition of tills which is common in the south-central part of the province. Drift in this part of the province has been divided into three groups: Empress Group, Sutherland Group, and Saskatoon Group (Figures 2.1-6 and 2.1-7) (Christiansen 1992). Other evidence of glacial deposition in the study area include glacial erratics, eskers, and pimple mounds (Figure 2.1-3) (Irvine and Dale 2012; McDougall 2000).

Also of note for this region are the glaciolacustrine sediments deposited by Lake Elstow. These deposits consists of clay loam and silty clay loam ranging from 0.3 to 3 m in thickness, though commonly less than 1.5 m thick, with lenses of sand and gravels which were likely the result of wave action in areas of higher topography (Greer and Christiansen 1963).

2.1.3 Hydrology

Not surprisingly the geology of the study area has influenced the local hydrology. As described above, the geology of the prairies is dominated by clay-rich glacial deposits underlain by Cretaceous shale bedrock. As a result, groundwater flow is inhibited due to the low permeability of the shale and glacial clay-rich deposits and therefore lake water levels in the region are often not significantly influenced by groundwater flow. However, permeable gravel and sand aquifers are present throughout the region and where these intersect with lakes, groundwater can play an important factor on the hydraulic budget of closed-basin waterbodies (van der Kamp et al. 2008).

In the Wynyard area (NTS 72P), the Empress Group Aquifers are the most extensive aquifer unit, followed by an aquifer in the Saskatoon Group intertill/interglacial sands and gravels and aquifers in the Sutherland Group (Simpson 2000). Between these aquifers, shale and clay till units form aquitards that impede the movement of groundwater. Within this area, the

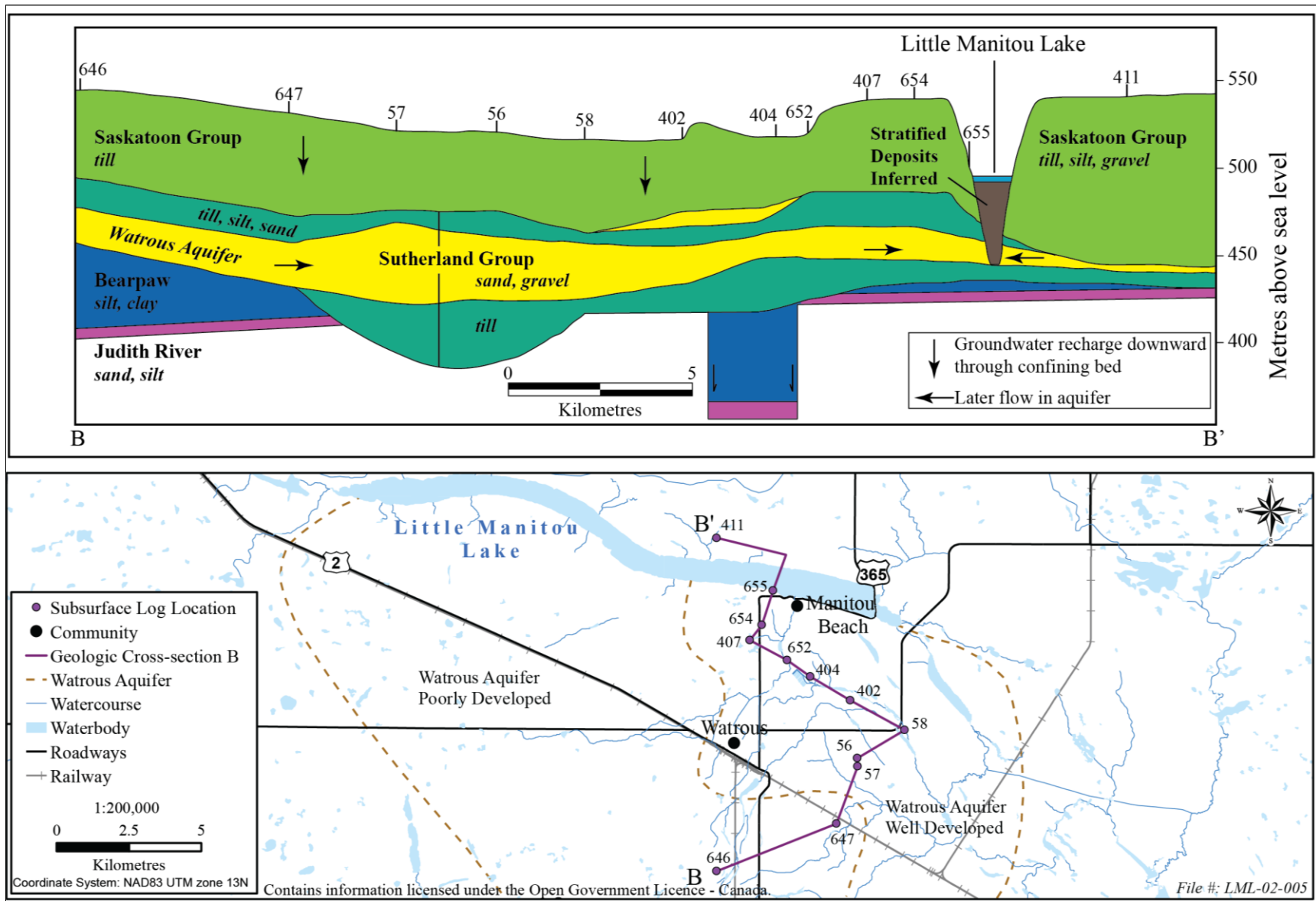


Figure 2.1-7. Aquifer, groundwater, and geological cross-section of the Little Manitou Lake area (after Henry et al. 1990:Figure 4.17).

Allan Hills in the west and the Touchwood Hills in the east are the two major groundwater recharge areas which supply the aquifers in the region.

While the hydrologic budget of Little Manitou Lake is influenced by surface runoff and seasonal evaporation it is also influenced by inflow from the Watrous Aquifer, an intertill aquifer in the Sutherland Group (Figure 2.1-7) (Henry et al. 1990). The lake acts as a discharge area for this aquifer, with water draining into the alluvium underlying the lake. Water tested throughout this aquifer system has been found to have a wide variability of Sodium Adsorption Ratios (SAR), ranging from low to very high sodium-enriched water (Henry et al. 1990; Maathuis and Schreiner 1982). Aquifers within the Sutherland Group are closer to bedrock and as such glacial tills may have incorporated more sodium-rich shale resulting in higher SAR values and sodium-enriched water being delivered to the Little Manitou Lake basin (Henry et al. 1990). See Section 2.3.2 for further details pertaining to the hydrology of the Little Manitou Lake basin.

2.2 Paleoclimatic and Paleoenvironmental Background

Interpretation of climatic change throughout the Holocene is often based on a synthesis of data obtained from studies of lacustrine deposits. Lake levels and related characteristics (e.g., salinity levels) of prairie lakes have changed dramatically over time due to changing environmental conditions. The lakes on the Northern Plains are diverse in water composition and lacustrine sedimentary characteristics and are found in several distinct climatic and vegetational zones ranging from arid and semiarid prairie grasslands to cool, wet boreal forest conditions (Sack and Last 1994). In addition, many of these lakes are situated within closed-basins, thus the influence of a semi-arid climate has caused many of them to develop a high degree of salinity (Rawson and Moore 1944). While the vast majority of lakes on the Northern Plains are shallow and ephemeral, the region contains several of North America's largest and deepest salt lake basins. Closed-basin lakes can be particularly sensitive to even minor changes in local and regional hydrology, as well as short and long-term climatic fluctuations. These are reflected in marked changes in their chemical compositions through time (van der Kamp et al. 2008). Such fluctuations are typically studied through the evaluation of a number of different proxy indicators (e.g., changes in lacustrine deposits, fossil pollen, stable isotopes, phytoliths, plant macrofossils, etc.) since not all proxy indicators will respond in the same way to changing meteorological, hydrological, or climatic conditions.

A summary of Holocene paleoclimatic changes in southern Saskatchewan, including data from neighbouring regions of the Northern Plains, is presented in Section 2.2.1. This is followed by a summary of the paleolimnological characteristics of Little Manitou Lake in Section 2.2.2. The recovered sedimentary sequence of Little Manitou Lake only dates back to approximately 2,000 years BP and is therefore paired with regional paleoclimatic and paleoenvironmental proxy indicator data. Studies conducted in this broader region provide a reasonably comprehensive understanding of environmental changes and thus help to place Little Manitou Lake within a longer paleoenvironmental sequence.

2.2.1 Holocene Climate Change in Southern Saskatchewan

Climatic change on the Northern Plains has been a topic of investigation for many years with evidence of millennial-scale climatic shifts during the Holocene emerging from paleoclimatic records (e.g., Sauchyn 1997). Antevs (1955) developed a framework for the Great Plains which divided the Holocene into three sub-periods: Anathermal (9,000-7,000 years BP), Altithermal (7,000-4,500 years BP), and Medithermal (4,500 years BP to present). He describes the Anathermal, the initial period after glacial recession, as a cool, wet period. This contrasts with the next period, the Altithermal, which was much warmer and arid. The most recent period described by Antevs, the Medithermal, began with cooler and humid conditions than the Altithermal and marked the onset of current climatic conditions.

This broad framework provided the basis upon which further research has been built that has refined the transitions between periods at a regional scale. The terminology associated with these periods has changed; most researchers no longer use Antevs' terminology although they do consider the three sub-periods described below. For this thesis, a framework based on Leyden et al. (2006:89-91) will be used as illustrated in Figure 2.2-1 and expanded on in the following sections.

The **Late Pleistocene and Early Holocene** (~11,000 to 7,000 years BP) was a transitional period of warming relative to the conditions at the end of glaciation (Leyden et al. 2006). The **Middle Holocene** (~7,000 to 5,000 years BP) began with a major climatic shift at the end of the Early Holocene, characterized by warmer, drier conditions than during the Early Holocene or conditions which occur today. It was during this period that these warming conditions reached a maximum (also known as the Hypsithermal). The **Late Holocene** (~5,000

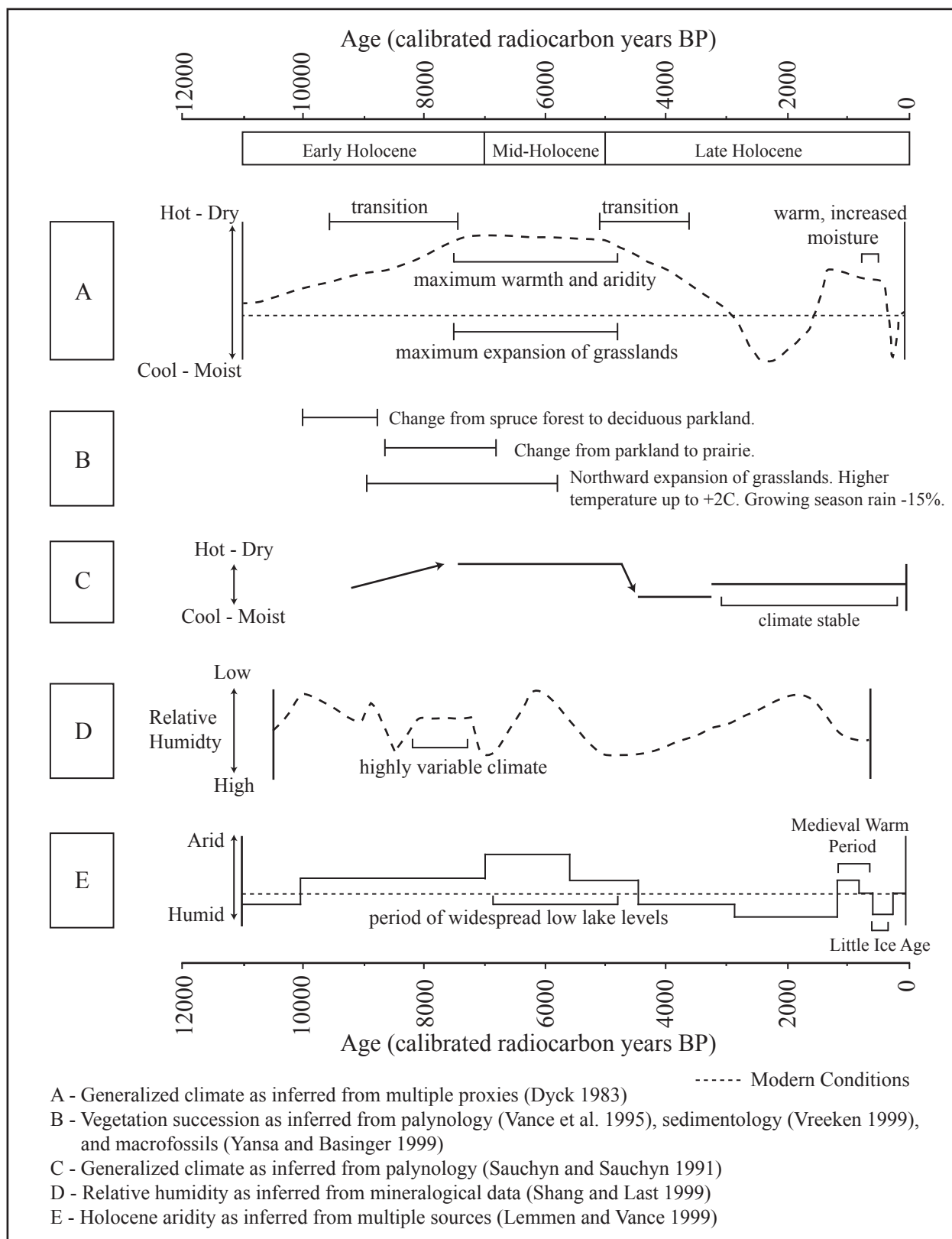


Figure 2.2-1. Holocene climate change in Southern Saskatchewan: A multi-proxy panorama (after Leyden, et al. 2006:90).

years BP to present) brought about another shift in climatic conditions eventually resulting in a transition to cooler and moister conditions than present between 3,000 and 2,000 years BP. Subsequent episodes of warm/arid conditions (the Medieval Warm Period - 1,100 to 800 years BP) and cool/humid conditions (Little Ice Age - 500 to 100 years BP) also occurred (Leyden et al. 2006).

2.2.1.1 Early Holocene Climatic Conditions

The Early Holocene on the Northern Plains was a time of dramatic and rapid climatic and environmental change (Figure 2.2-1) (Last et al. 1998). Immediately following deglaciation, or approximately 10,000 years BP, maximum postglacial warmth and aridity were established in central Alberta. Similar conditions were established further east on the Northern Plains by 8,000 years BP, reflecting a progressively later shift in Holocene climate from southwest to northeast (Vance et al. 1995). It was during this period that a vast region once occupied by the Laurentide and Cordilleran ice sheets became available for colonization by plants, animals, and humans.

Few lacustrine stratigraphic sequences extend to the early Holocene on the Northern Plains; however, those records that do exist suggest a dynamic period with rapid climatic and hydrologic changes. The analysis of the Clearwater Lake (Figure 2.2-2) record indicates dramatic fluctuations of water chemistry and limnological conditions during the Early Holocene (Last et al. 1998). Data from the earliest phases of the lake suggest that it contained freshwater which originated during deglaciation from melting ice. Similar freshwater conditions have also been observed in the Early Holocene phase of the paleolimnological records of Oro Lake (Last and Vance 2002) and Medicine Lake (Figure 2.2-2) (Kennedy 1994).

Analysis of early Holocene pollen and plant macrofossil records from southern Saskatchewan suggest a shift in vegetation from spruce forest to deciduous parkland, followed by the northward expansion of prairie grasslands (Figure 2.2-1) (Sauchyn 1997; Vance et al. 1995; Yansa and Basinger 1999). This interpretation differs from that of Ritchie (1976) based on several southern Saskatchewan and Manitoban lake records (Herbert, Hafichuk, Scrimbit, Sewell, Riding Mountain, and Russell lakes - Figure 2.2-2) which he argued indicated a shift from spruce forest directly to a prairie environment at about 11,000 years BP in the southernmost parts of the prairie provinces and by 9,500 years BP in areas south of Saskatoon, SK. Similar to Ritchie's findings, Grimm et al. (2011) described an open spruce parkland environment during the

late Pleistocene which gave way to a grassland environment in the early Holocene based on data from Kettle Lake (Figure 2.2-2). This broad variability in the late-glacial and early post-glacial environments is also reflected in lacustrine deposits of Guardipee Lake, Antelope Playa, and Bear Butte Lake (Figure 2.2-2) in the Northwestern Great Plains which indicate a treeless vegetation consisting of sages and grasses approximately 12,000 to 13,000 years BP (Barnosky et al. 1987; Markgraf and Lennon 1986). In sum, it would seem that what is now the central and northern Plains may have displayed a range of floral responses to environmental change during the late Pleistocene to early Holocene transition (*cf.*, Barnosky et al. 1987) .

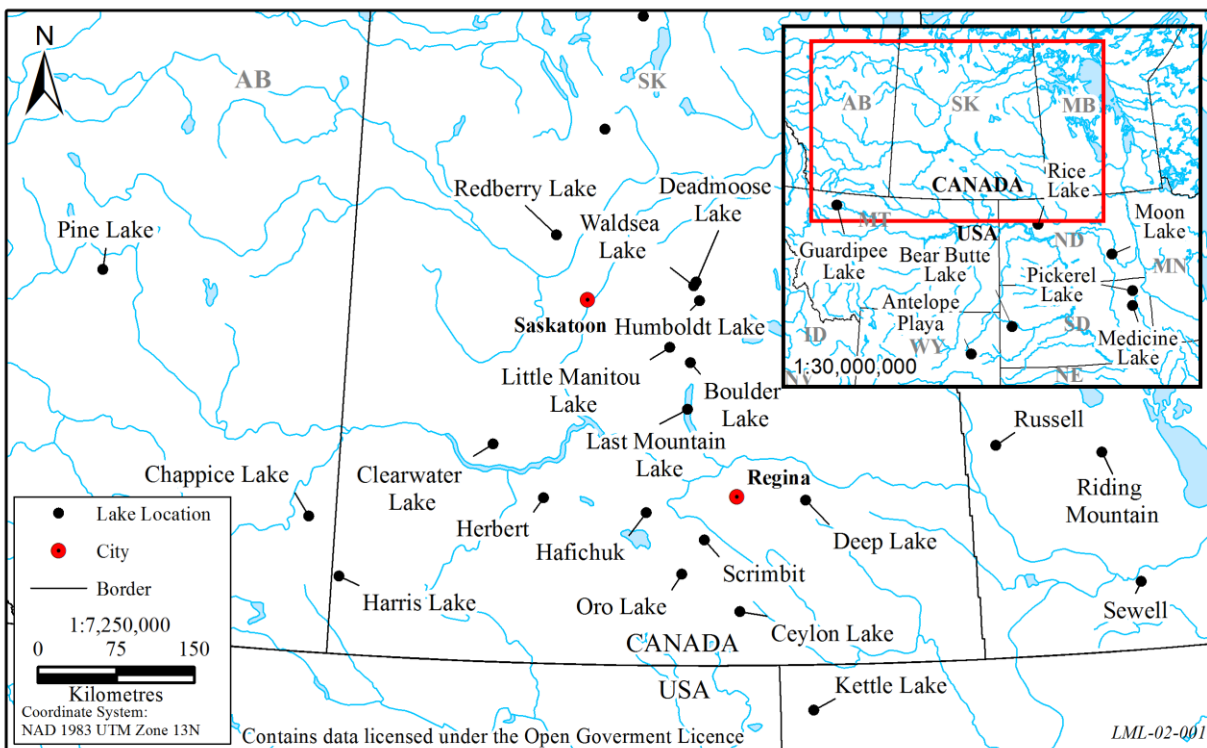


Figure 2.2-2. Lakes on the Northern Great Plains discussed in this chapter.

2.2.1.2 Middle Holocene Climatic Conditions

Grimm et al. (2011) suggest that the Middle Holocene was a period characterized by great variability in moisture as a result of severe droughts alternating with more humid periods. The Hypsithermal, which was a Mid-Holocene warming trend, has been a subject of much research and controversy (Stead 2013). The debate centres around how changing climatic conditions would have influenced cultural groups on the Northern Plains. Secondly, the terminology employed to describe this period of climatic warming (e.g., altithermal, mid-Holocene climatic optimum, megathermal [Antevs 1995; Judson 1953]) has been a topic of

discussion. The term Hypsithermal, first introduced by Deevey and Flint (1957), is the currently preferred term due to its ability to express a period of high temperature (*hypsi thermal*) and its long time frame stretching from 9,000 to 2,500 years BP, taking in several thermal maxima and intervening cooler phases, and the suggestion of this period being time-transgressive from region to region (Deevey and Flint 1957; Wright 1976). Deevey and Flint elaborate why other terms are insufficient for describing this period:

(i) *optimum* is subjective and, when it is applied interchangeably in arid and humid countries, ambiguous; (ii) *thermal maximum*...applies to a stratigraphic horizon or to a point in time, not a zone or its time equivalent; (iii) *xerothermic* usually implies too much that is unknown and is at best of local application; (iv) *altithermal* is an etymologic hybrid and its stratigraphic basis has never been defined - as it is dated, it applies to only part of the zone in question; (v) *megathermal*, although correctly formed, is uninformative as to how "big" or "mega" was the temperature...[1957:182].

On the Northern Plains, it is argued that the Hypsithermal began between 9,000 and 7,000 years BP and ended between 6,000 and 4,000 years BP, exhibiting several climatic maxima which were bisected by a number of cooler phases (Figure 2.2-1) (Anderson et al. 1989; Barnosky et al. 1987; Vance et al. 1995) although date ranges associated with the Hypsithermal vary regionally across the Northern Plains. Many lacustrine sites which have been subject to paleoenvironmental investigation on the Northern Plains indicate high salinity during this period. This has been interpreted to reflect episodes of lower water levels resulting from evaporation associated with increased temperatures and aridity (Figure 2.2-1) (Last et al. 1998). Sauchyn and Vélez (2007) summarize time ranges for maximum aridity for a number of lakes in the Northern Plains: Oro Lake exhibited an abrupt change at 9,300 years BP, Chappice Lake from 7,300 to 6,000 years BP, Harris Lake from 7,700 to 5,000 years BP, Ceylon Lake at approximately 6,000 years BP, and Deep Lake from 7,200 to 6,400 years BP (Figures 2.2-2). Data from Kettle Lake indicate a later date for the most intense drought, occurring at 5,450 years BP (Grimm et al. 2011) while peak aridity at Medicine Lake occurred between 5,500 to 4,500 years BP (Kennedy 1994). It was also during this period of climatic change that vegetation shifts resulting in prairie grasslands expanding to their maximum extent while boreal forest margins were pushed north and eastward (Vance et al. 1995; Vreeken 1999; Zoltai and Vitt 1990).

2.2.1.3. Late Holocene Climatic Conditions

While the Late Holocene has also been characterized by climatic variability (Grimm et al. 2011), in general, moister and cooler conditions than present returned to the Northern Plains, evidenced by rising lake levels and changes in fossil pollen deposits, among other proxy indicators (Figure 2.2-1) (Sauchyn and Vélez 2007). This cooler, moister trend is thought to have contributed to the onset of the Neoglacial advance between approximately 5,000 to 2,000 years BP, defined as a "climatic episode characterized by rebirth/and or growth of glaciers following maximum shrinkage during the Hypsithermal interval" (Porter and Denton 1967:205, Lamoureux and Cockburn 2005). This shift to cooler and moister conditions led to the advance of alpine glaciers in the Rocky Mountains. On the Northern Plains, the drop in average temperatures resulted in more favourable conditions for human occupation as a result of the establishment of dependable natural resources (Mann 2002; Vance 1991). Vance (1991) has postulated that these favourable conditions are reflected culturally by the establishment of populations which archaeologists refer to as Oxbow (*cf.*, Buchner 1981). These climatic changes may also be reflected in higher lake levels at Chappice Lake between 6,000 and 4,000 years BP and changes in the pollen record at Harris Lake between 5,000 and 3,200 years BP (Figure 2.2-2) (Sauchyn and Sauchyn 1991).

The last 2,000 years BP on the Northern Plains can be divided into two primary climatic phases. The first and earlier phase, which persisted until approximately 700 years BP, is known as the Medieval Warm Period, a period of increased aridity which is reflected by low lake levels and increases in salinity (Peck 2011; Vance 1991; Vance et al. 1995). Interestingly, Vance (1991) has suggested that the decline of the Avonlea cultural phase seems to correspond with the onset of the Medieval Warm Period. Evidence of this warming period has been observed in the sedimentary record of Redberry Lake (Figure 2.2-2) (van Stempvoort et al. 1993). The second and later phase, from approximately 500 to 100 years BP, saw the return of cooler and moister conditions. This phase has been termed the Little Ice Age, during which glacial advances occurred in the Rocky Mountains and Europe (Grove 1988; Lamb 1972; Lemmen and Vance 1998; Sauchyn and Beaudoin 1998). While evidence of these climatic changes have been observed in some lacustrine deposits across the Northern Plains (*cf.*, Pine Lake - Campbell et al. 2000; Rice Lake - Yu et al. 2002) they are not always discernible (*cf.*, Harris Lake - Sauchyn and Sauchyn 1991), perhaps due to a number of factors such as local intensity, hydrologic

characteristics of the lake being studied, record resolution issues, or perhaps as a function of the specific proxy indicators being assessed (Lemmen and Vance 1999; Sauchyn and Beaudoin 1998).

2.2.2 Paleolimnology of Little Manitou Lake

The evaluation of sedimentary records from prairie lakes can provide a glimpse of the continuous record of past environmental conditions that existed during periods of precontact human occupation. A growing number of studies have assessed paleolimnological data with a goal toward elucidating relationships between precontact occupation and paleoenvironmental conditions (*cf.*, Cyr et al. 2011; Greiser et al. 1985; Klassen 2004; Yansa 2007; Vance 1991). Little Manitou Lake, with its positioning adjacent to the Little Manitou Lake archaeological complex, provides paleoenvironmental information that upon comparison to specific archaeological site information can assess how precontact populations responded to changing climatic conditions.

A detailed study of the paleolimnology of Little Manitou Lake was undertaken in the early 1990s by Sack and Last (1994). Prior to this, despite a history of intensive recreational use and development dating back to the 1910s (see Chapter 3), very little was known about the geolimnology of the lake (Last 1991). Through the evaluation of paleolimnological sequences, dating back to approximately 2,000 years BP, an interpretation of the changing characteristics of this lake has been postulated (Sack and Last 1994). Sack and Last (1994) are careful to note that good chronological control was difficult to obtain from the cores taken from Little Manitou Lake due to a number of factors including: changes in chemical composition and/or temperature through time that can result in substantial changes in mineral precipitation and poor organic preservation (conditions which are inherent to many salt lakes on the Great Plains [Last and Ginn 2005]), contamination problems from Cretaceous and Tertiary coals and organic-rich shales that are present in the bedrock geology underlying the area (see Section 2.1.2), and generally low organic productivity in salt lakes. Despite this, a radiocarbon date of $1,950 \pm 90$ years BP was obtained from finely disseminated organic matter (physically small organic material which is dispersed throughout the matrix of a soil horizon [Canarache et al. 2006]) at the base of Facies D from which a tentative time scale was constructed based on assumed sedimentation rates (Figure 2.2-3; *facies* is defined in the Glossary) (Sack and Last 1994).

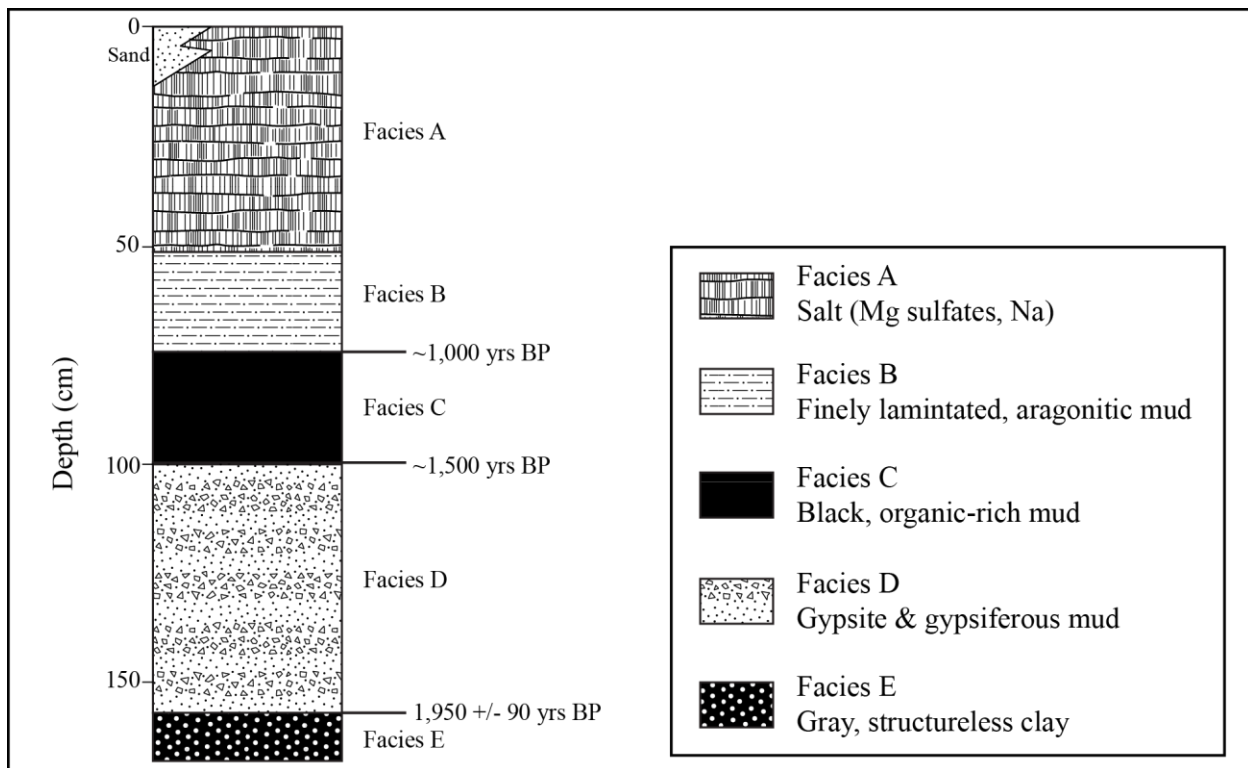


Figure 2.2-3 Schematic of Little Manitou Lake lithostratigraphic profile (adapted from Sack and Last 1994:203).

Interpretation of the lacustrine record indicates that Little Manitou Lake was a deep, relatively freshwater lake prior to 2,000 years BP (Sack and Last 1994); the temporal and spatial extent of this freshwater lake are not currently known due to the limited recovery of sediments from Facies E in the cores which were analyzed (Figure 2.2-3, Facies E). From approximately 2,000 until 1,500 years BP the lake underwent an abrupt change during which water levels dropped and the lake became an ephemeral mud/salt flat and/or playa basin (Figure 2.2-3, Facies D). Water in the basin during this period was compositionally complex reflecting shallow, hyposaline calcium sulfate (Ca-SO_4) groundwater mixing with concentrated saline to hypersaline surface brines. In addition, water in the lake had high magnesium-calcium (Mg/Ca) ratios which fluctuated greatly in response to precipitation, groundwater, and surface runoff. It was during this period that Sack and Last note that "it is tempting to attribute this period of saline playa conditions to a more arid climate" (1994:209).

The lithostratigraphy of Little Manitou Lake reflects a gradual deepening of the lake starting approximately 1,500 years BP and continuing over the next several hundred years, eventually returning the basin to a perennial lake (Figure 2.2-3, Facies C) (Sack and Last 1994). The lake at this time was estimated to have been 20 m deep, though still a closed-system, having

a saline chemistry and a high to very high Mg/Ca ratio. The lake during this period also exhibited stratified (meromictic) water column conditions due to increases in fresh water inputs. These conditions persisted until shortly after 1,000 years BP.

The salinity of the lake increased further after approximately 1,000 years BP which marks a significant change of the subaqueous salt precipitation (Figure 2.2-3, Facies B) (Sack and Last 1994). It is thought that lake level fluctuations during this period were similar to those seen today; a perennial lake between 5 to 6 m deep influenced by seasonal fluctuations. The increase in salinity during this period may reflect climate conditions commonly associated with the Medieval Warm Period.

The most recent lacustrine deposits in Little Manitou Lake consists of soluble evaporate salts and are the most abundant/thickest stratigraphic unit recovered (Figure 2.2-3, Facies A). These salts, mainly sodium sulfate (Na_2SO_4), result in a brine of about 100 to 200 ppt (Sack and Last 1994). The lower part of the sedimentary sequence contains an elevated amount of magnesium (Mg) and mixed magnesium-sodium salts suggesting that the activity of Mg^{2+} in the water was high. In addition, it appears that the sodium content increased for a short interval. While this could reflect a change in the brine composition of the lake, it could also relate to slightly cooler temperatures (perhaps indicative of cooling associated with the Little Ice Age) as Na-sulfates show a stronger decrease in solubility with decreasing temperatures than do Mg-sulfates. This elevated Na_2SO_4 phase was short-lived with the lake soon returning to conditions similar to those of today (see Section 2.3.2).

2.2.2.1. Evaluation of Little Manitou Lake Paleolimnology with Regional Proxy Data

The evaluation and comparison of proxy data from nearby lakes is essential to extend the regional temporal record of paleoclimatic change, given Little Manitou Lake's relatively limited paleolimnologic record, and to tie the paleolimnologic record of Little Manitou Lake to Holocene paleoenvironmental trends on the Northern Plains. In a study carried out by Laird et al. (2003) on six lakes located across the Northern Great Plains, they suggest that "large-scale multicentennial shifts in mean climatic conditions seem to exhibit regional coherency" (Laird et al. 2003:2487). As such, similar trends between the paleolimnology of Little Manitou Lake and that of regionally located lakes may reflect similar conditions. Beaudoin (1993), however, cautions that comparisons within regions should be made with the closest available proxy data

stating that "...How these environmental trends might be reflected in the vegetation near specific archaeological sites may be hard to infer, particularly if the nearest paleoenvironmental record is far distant or from a different ecophysical zone" (Beaudoin 1993:98). Therefore, comparative analysis of regional lake records has been limited to Humboldt, Waldsea, Deadmoose, and Redberry lakes (Figure 2.2-2), all located within 200 km of Little Manitou Lake and within similar modern climatic zones.

Paleoclimatic evaluation carried out for Humboldt Lake, located approximately 53 km northeast of Little Manitou Lake (Figure 2.2-2), used the remains of diatoms in the lake sediments to estimate past water salinity and infer climatic changes (Michels et al. 2007). Three different zones were identified in the sediments of Humboldt Lake. Diatoms recovered from Zone A, ranging from ~5,000 to 3,900 years cal BP, suggest a period of variable climatic conditions with primarily hyposaline taxa and some short-lived freshwater species. Zone B, ranging from ~3,900 to 1,700 years cal BP, was characterized by a sharp decline in freshwater species from which more arid conditions can be inferred. Zone C, ranging from ~1,700 years cal BP to present, has a return of freshwater taxa indicating wetter conditions. Laird et al. (2003) also evaluated Humboldt Lake using diatom data from 400-1850 years cal AD (1,500-100 years BP). They found that "distinct patterns of abrupt change in the Northern Hemisphere are common at or near the termination of the Medieval Warm Period (*ca.* AD 800-1300 [1,150-650 years BP]) and the onset of the Little Ice Age (*ca.* AD 1300-1850 [650-100 years BP])" (Laird et al. 2003:2487).

Comparing the trends observed in Humboldt Lake to those seen in Little Manitou Lake, the arid conditions observed in Zone B could be indicative of the low water levels and warmer conditions observed in the paleolimnology of Little Manitou Lake. The changes observed in Zone C due to wetter conditions might also be compared to the deepening of Little Manitou Lake observed at approximately 1,500 years BP. In addition, it is possible that the drying trend observed by Laird et al. (2003) at Humboldt Lake around 1,150 years BP reflects the environmental changes that caused the increase in salinity at Little Manitou Lake at approximately 1,000 years BP.

Waldsea Lake, located approximately 63 km north-northeast of Little Manitou Lake (Figure 2.2-2), is likely a remnant of glacial Lake Fulda, which existed approximately 10,000 years ago (Schweyen 1984). Waldsea Lake and Deadmoose Lake (discussed below) are part of

chain of basins that internally drain an area of approximately 14,000 km² (Last and Slezak 1986). Sedimentary deposits from Waldsea Lake date back to the mid-Holocene. The earliest deposits (~6,000-4,500 year BP) are laminated with chemically precipitated sediments containing numerous exposure horizons, desiccation zones, and cemented beds. The presence of such bedding features is suggestive of relatively low moisture and represent deposition in a shallow, saline playa environment where water levels fluctuated from several metres in depth to dry conditions (Last et al. 2002). Between 4,500 and 4,000 years BP the lithostratigraphy and pollen records suggest that Waldsea Lake was hypersaline and situated within an aspen parkland (Last and Schweyen 1985; Schweyen and Last 1983). Last et al. (2002) also suggest that during this period the lake was chemically complex, exhibiting relatively deep, meromictic (chemically stratified) conditions. Transition to cooler wetter conditions occurred between 4,000 and 2,800 years BP, evidenced by increasing abundances of pine and spruce pollen. In addition, the mineralogy is diagnostic of deeper water. Combined, this evidence would seem to reflect transition from the Hypsithermal to the cooler, moister climate of the Late Holocene. Following this period, between 2,800 to approximately 2,000 years BP, a sharp increase in grass pollen and corresponding decrease in both pine and spruce pollen occurs contemporaneously with a return to mudflat/playa conditions (Last et al. 2002; Last and Schweyen 1985; Last and Slezak 1986). By about 2,000 years BP, an assemblage of pine, birch, grass, and sage pollen, in proportions similar to those observed today, was established (Last and Slezak 1986). Waldsea Lake also experienced elevated evaporation brought about by warmer climatic conditions between 2,000 and 1,500 years BP. This period could be reflective of the climate that brought about the low water and playa mudflat conditions also observed at Little Manitou Lake.

Deadmoose Lake, which is situated 1.5 km northeast of Waldsea Lake and approximately 67 km north-northeast of Little Manitou Lake (Figure 2.2-2), likely also formed from the remnants of glacial Lake Fulda in combination with ice-block meltout as evidenced by several deep depressions in the lake floor (Last and Ginn 2005). Like Waldsea Lake, the sediments evaluated from Deadmoose Lake indicate that the lake experienced fluctuations in hydrology and water chemistry throughout the Late Holocene (Last and Slezak 1986). Deadmoose Lake was 10 m lower and much smaller between 2,000 and 1,500 years BP, likely in response to increased evaporation due to a warmer climate, a condition similar to that seen at Little Manitou Lake (Sack and Last 1994).

Redberry Lake, a topographically closed-basin lake located approximately 153 km northwest of Little Manitou Lake in a transition zone between semi-arid grasslands to the southwest and boreal forest to the northeast (Figures 2.2-2), also provides data regarding changing environmental conditions during the Late Holocene. The partially-laminated aragonite-rich sediments of Redberry Lake extend back to approximately 2,500 years BP and reflect fluctuations in paleohydrology (van Stempvoort et al. 1993). Based on the evaluation of stable isotopes, sediment pigment, and mineralogy, van Stempvoort et al. (1993) suggest that between 2,500 and 1,500 years BP a period of warm and dry climatic conditions occurred, similar to that seen at Little Manitou Lake. This period was followed by relatively humid and cooler conditions with episodes of warmer/drier conditions between 1,100 to 900 years BP (Medieval Warm Period - similar to conditions at Little Manitou Lake during this period) and 600 to 300 years BP (van Stempvoort et al. 1993).

Overall, proxy data from these regional studies reflect similar climatic trends as those seen at Little Manitou Lake over the last 2,000 years. Humboldt and Waldsea lakes are the closest lakes to Little Manitou Lake and have the longest temporal paleolimnologic records of the four comparative lakes considered. They correlate favourably with the paleolimnologic record of Little Manitou Lake and also provide a suggestion for what climatic conditions may have been like prior to ~2,000 years BP. Deadmoose and Redberry lakes also provide confirmation that similar climatic trends were seen at all five lakes over approximately the last 2,000 years BP.

2.3 Current Environmental Setting

The physical characteristics of the modern environment in the Little Manitou Lake region can shed insight on how current conditions, and those of the recent past, may have influenced the modern landscape and the archaeological record.

2.3.1 Ecology and Climate

Today, the topography in the Little Manitou Lake region is characterized by hummocky, undulating to rolling terrain with a local relief of a maximum of 12 m. The low-laying valleys and plains are evidence of the glacial activity once present, as are the numerous small lakes and wetlands found throughout the area (Acton et al. 1998; Greer and Christiansen 1963).

The study area falls within the Moist Mixed Grassland ecoregion of Saskatchewan, an area typified by a semi-arid climate consisting of short, warm summers and long, cold winters with a mean annual precipitation of 350 to 400 mm. This ecoregion also forms the northern extent of open grassland in Saskatchewan and Alberta. Mid-grasses, including spear grass (*Hesperostipa comata*) and wheat grass (*Elymus lanceolatus*, *Pascopyrum smithii*), and short-grasses, including blue grama (*Bouteloua gracilis*), are commonly found growing in mixed stands. Other vegetation found in this ecoregion include buckbrush (*Symphoricarpos occidentalis*), chokecherry (*Prunus virginiana*), wolfwillow (*Elaeagnus commutata*), saskatoon (*Amelanchier alnifolia*), trembling aspen (*Populus tremuloides*), and thorny buffaloberry (*Shepherdia argentea*) (Acton et al. 1998; Budd et al. 1987; Saskatchewan Forage Council 2002).

Recent intensive agriculture has led to the loss of much of the natural vegetation once found in this ecoregion, with approximately 80% of the ecoregion subject to cultivation (Acton et al. 1998; Hammermeister et al. 2001; Nernberg and Ingstrup 2005). However, some areas of native prairie grassland do remain, typically in areas that are too wet, sandy, stony, or hilly to cultivate. Fortunately, large patches of native prairie grassland are located along the northern and southern sides of Little Manitou Lake, portions of which are used as pasture for livestock and have been designated as protected wildlife habitat (*Wildlife Habitat Protection Act* 1992, Schedule 588 and 607).

Little Manitou Lake also falls within the Prairie Pothole Region which is characterized by kettle features: shallow depressional waterbodies created by the melting of remnant glacial ice (Millar 1976). These wetlands play important hydrological and ecological roles, adding to regional diversity and providing seasonal habitat for more than half of North America's waterfowl (Ogaard et al. 1981). Little Manitou Lake is an important waterbody used by thousands of migratory birds that pass through the region annually (Bird Studies Canada 2010). As a result, waterfowl hunting has been a common recreational activity in the area which continues today (Acton et al. 1998).

The pothole wetlands in the region are typically not fish bearing, likely because they are closed basins and are ephemeral in nature. Similarly, Little Manitou Lake and Strap Lake, to the northwest, are not fish bearing due to elevated salinity levels, although Little Manitou Lake does support a population of brine shrimp (*Artemia salina*) (Persoone et al. 1980; see also Chapter 3).

Interestingly, the small unnamed lake between Strap and Little Manitou lakes, known locally as Waterman Marsh, supports fathead minnows (*Pimephales promelas*) and brook stickleback (*Culaea inconstans*) (Rescan 2012a).

2.3.2 Regional Hydrology

Little Manitou Lake has a larger surface area (13.3 km²) and is deeper (5.9 m maximum depth and 3.8 m mean depth) than most present-day lakes on the Northern Plains (Sack and Last 1994). The lake basin has a maximum length of approximately 20 km (roughly on an east-west axis) and maximum width of approximately 1 km with very steeply sloping sides and a flat, featureless bottom (Figure 2.1-4). As noted above, Little Manitou Lake is situated within a closed-basin with a spill point approximately 24 m above the present-day lake level (Sack and Last 1994). There are no major perennial streams that flow into the lake, although it is subject to infrequent seasonal surface runoff. Typically, the hydrologic budget of the lake is controlled by groundwater influx and loss by evaporation.

The water in Little Manitou Lake is hypersaline; the average salinity today is 180 ppt (or 180,000 milligrams per litre; ocean salinity typically ranges between 34 ppt and 36 ppt) (Sack and Last 1994; Saskatchewan Watershed Authority 2008). This high salinity gives the water a specific gravity of 1.06 (higher than that of seawater which is typically 1.028), making it very buoyant. The mineral salt characteristics of the water today are dominated by magnesium (Mg²⁺), and sulfate (SO₄²⁻) as well as sodium (Na⁺), chlorine (Cl⁻) and potassium (K⁺). These minerals give the water a distinctive metallic bronze colour (Schellenberg 1996). Historically, the lake was chemically stratified (meromictic) though with considerable seasonal variation. These seasonal changes in salinity result from freezing for four to six months each year, inundation with spring surface runoff, and rapid evaporation during the relatively short summer period (Rawson and Moore 1944). These seasonal fluctuations typically result in rapid increases in salinity from May to September. Table 2.3-1 outlines the chemically stratified nature of the lake as measured in 1940. For reasons that remain yet to be explained, the lake has been well mixed since 1991 and no longer exhibits pronounced seasonal meromictic characteristics (Sack and Last 1994). Not surprisingly, the lake and its unique mineral properties have played a significant role in the use and development of the area (see Chapter 3).

Table 2.3-1. Seasonal changes and vertical differences in the salinity of Little Manitou Lake, May to September 1940 (after Rawson and Moore 1944:148).

Depth	May 17, 1940	July 17, 1940	September 12, 1940
Surface	105,400 ppm	120,300 ppm	147,600 ppm
Bottom (4 m)	104,000 ppm	157,000 ppm	167,800 ppm

Although today the water levels of Little Manitou Lake are largely determined by the balance of precipitation, flow from mineral springs and aquifers beneath the lake (see Section 2.1.3 for further information), and evaporation, since the 1970s water levels have been occasionally augmented by water delivered from the Saskatoon Southeast Water Supply System (SSEWSS) (Kehew and Teller 1994; Sack and Last 1994). In 1959 construction began on the Gardiner Dam on the South Saskatchewan River which ultimately resulted in the formation of Lake Diefenbaker (MacDonald 1999). The lake and dam now serve an important role in flood control for downstream areas and supply water for consumption, irrigation, industrial, and recreational use (Pomeroy et al. 2007). The SSEWSS delivers water from Lake Diefenbaker to Lanigan, SK through 158 km of canals, reservoirs (including the Zelma Reservoir to the northwest of the study area), and pipelines. SaskWater is currently upgrading existing infrastructure and extending the system further east to provide water to the proposed Jansen Potash Mine (Drury et al. 2012). In 1971, a drainage channel was constructed connecting Little Manitou Lake to the SSEWSS which has been used to help control levels in the reservoirs along the system during periods of excess precipitation and to raise the level of Little Manitou Lake during dry periods (Sack and Last 1994). In a report produced by the Saskatchewan Watershed Authority in 2008, it was noted that there was local concern regarding the influx of fresh water into the lake causing uncharacteristically high modern lake levels and a reduction in water salinity (Saskatchewan Watershed Authority 2008). The system was last used in 2008 to replenish water levels in the Dellwood Reservoir and was not used for water conveyance purposes between 2009 and 2011 (Rescan 2012a).

2.4 Chapter Summary

This chapter presented background information about glacial influences and the geological and hydrological setting for the study area. It also provided a summary of past climatic and environmental changes that have occurred throughout the region and more generally on the Northern Plains. The current environmental setting was reviewed to better understand how

the ecological diversity of the area has changed through time. This information was presented to provide a context for later site interpretations and to lay the foundation for discussion of how the physical characteristics of the landscape may have influenced past human occupation of the area.

Chapter 3

Archaeological and Historical Background

This chapter provides an overview of stone circle investigations which have been carried out on the Northern Plains and sets the current project within this framework. It also provides a summary of our current understanding of the archaeological environment and the historical background for the Little Manitou Lake region to provide context for past land use. For general accounts of precontact Plains cultures the reader is referred to Epp and Dyck (1983), Kornfeld et al. (2010), Reeves (1985), and Walker (2000), among others. While there is no single agreed-upon approach for describing the culture chronologies on the Northern Plains, Figure 3-1 illustrates a chronology based on Vickers (1986) with modified terminology based on Cyr (2006).

3.1 Stone Circle Investigations on the Northern Plains

Since the topic of this thesis deals predominately with stone circles sites, a summary of past archaeological investigations and the types of attribute data most commonly considered for this site type on the Northern Plains is warranted. This section places the current research into the broader context of stone circle investigations and sets the stage for evaluating how this study contributes to our overall understanding of stone circle sites and how they are investigated.

3.1.1 Stone Circles on the Northern Plains

Stone circles, also known as 'tipi (or teepee) rings', 'stone rings', 'habitation circles' or simply 'rings', are circular arrangements of rocks, having either single or double courses of stones. These rings typically pertain to habitation structures and account for a large proportion of visible archaeological features on the Northern Plains. As discussed further in Section 3.1.2, the function of such features was once a source of contention. However, current archaeological and ethnographic research suggests that stone circles measuring less than 10 m in diameter are likely

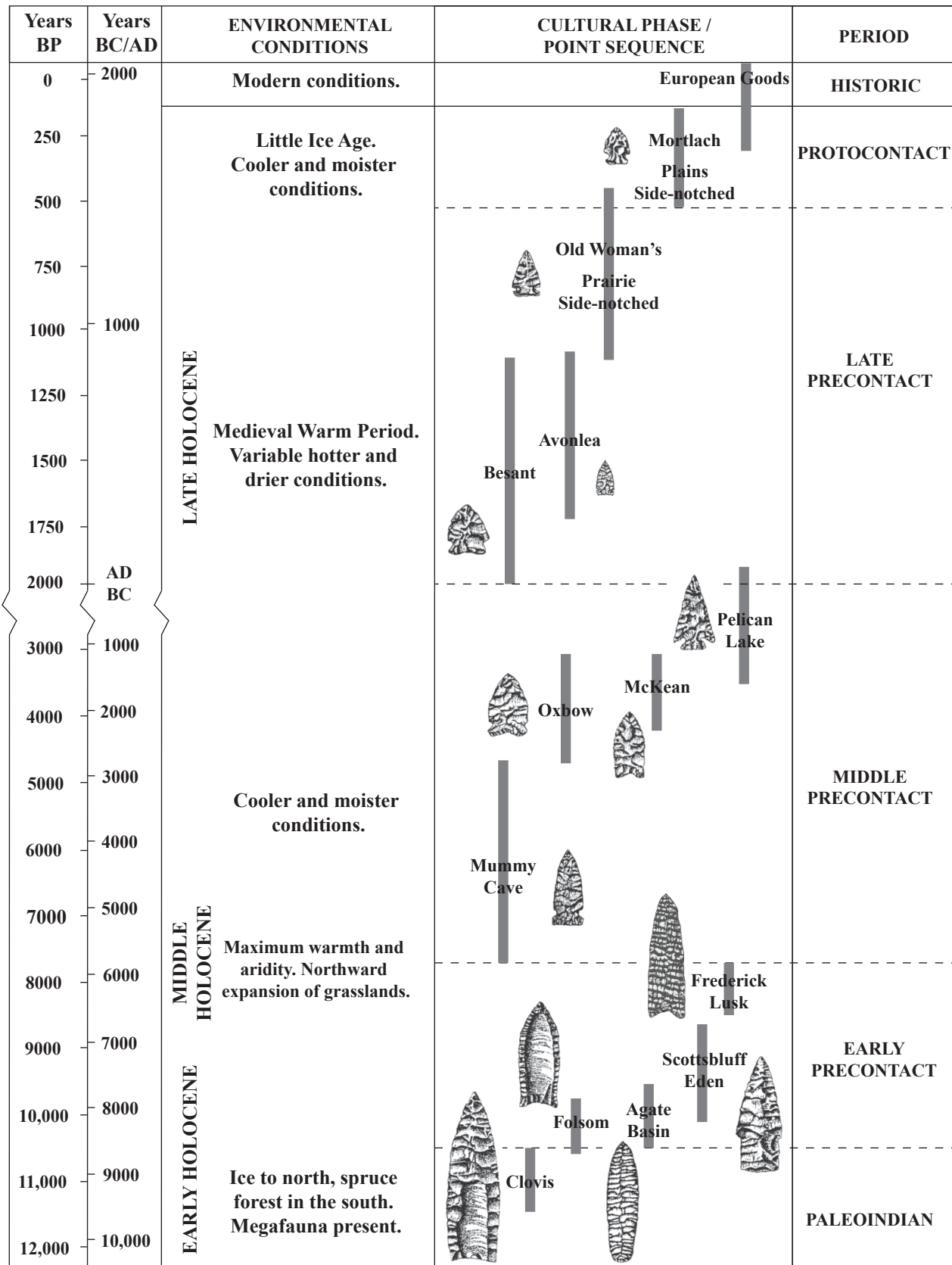


Figure 3-1. Cultural chronology of Northern Plains/Southern Saskatchewan (modified after Cyr 2006:17, Rollans 1990:15, Vickers 1986, and Wood 1998:12).

the remains of domestic structures; rings of rocks were used to weigh down the edges of lodge coverings in place of, or in addition to, wooden pegs or sod (Kehoe 1960; Wedel 1961) (Figure 3.1-1). What remains today denotes the abandoned locations of individual structures which were likely used for short-term seasonal occupation (Wilson 1983).

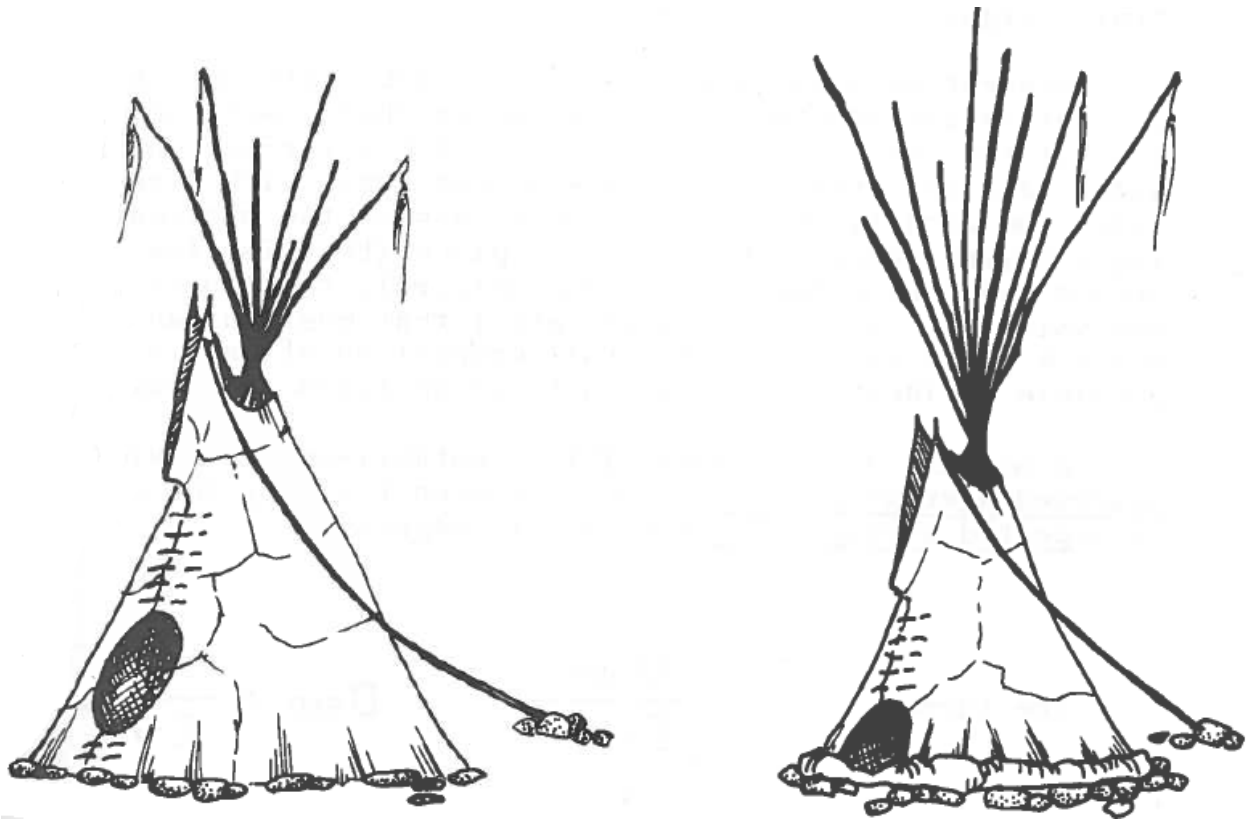


Figure 3.1-1. Tipi with stone weights, illustrating seasonal adjustments to optimize ventilation in summer (left) and heat retention in winter (right) (after Roll 1981:85).

3.1.1.1 Geographic Extent and Placement

Stone circle sites are found throughout the Great Plains region (Figure 3.1-2) and have been documented as far north as central Canada, as far south as central New Mexico, as far east as Iowa, and as far west as Utah and Idaho (Adams 1978; Mobley 1983). While such site types have been documented throughout the Great Plains, stone circle sites are most numerous in the Northern and Northwestern Plains, including southern Manitoba, Saskatchewan, Alberta, Wyoming, northern Montana, northern and eastern North Dakota, and eastern South Dakota (Brace 2005; Kay 1998; Wedel 1961), where glacial tills provided abundant stone for their creation (Kornfeld et al. 2010).



Figure 3.1-2. Map of the Great Plains cultural region with archaeological subdivisions (after Robertson 2011:182) and sites discussed in this section.

Stone circle sites are found in arid environments, on the open plains, in interior intermontane basins, in the foothills, and in some instances in the high mountains. They are commonly found in topographically elevated areas such as buttes, ridge tops, knolls, and terraces and along streams and dry arroyos (Kornfeld et al. 2010). Stone circle sites have also been documented in lowland settings but are less frequent (Mulloy 1952).

Sites vary from individual isolated rings to vast clusters exceeding 200 rings (Deaver 1989; Kornfeld et al. 2010). While many stone circles sites have been destroyed by agriculture and other developments, their numbers have been estimated to have been in the millions (if not billions) (Davis 1983b). In his 1970 publication, Forbis estimated the number of extant stone circles in southern Alberta to be as many as one million. Similarly, Deaver and Morter (1981) estimated over half a million stone circles in the once glaciated portion of northern Montana. This site type is also commonly found in combination with stone cairns and stone alignments, particularly on the Northern Plains (Dooley 2002).

3.1.1.2 Attributes of Stone Circles and Associated Deposits

Attribute data for stone circles includes a wide range of parameters, such as ring diameter, stone size/weight, and direction of wall gaps, which can provide information that can assist with site interpretation and comparisons within and between sites. Through the analysis of various attributes, archaeologists attempt to explore the adaptive strategies of the makers of stone circles, interpret the layout and organization of a camp, the number of people present, seasonality of occupation, and whether multiple occupations may have occurred over time. While not all researchers record the same attribute data, there has been an effort over the years to establish some consistency in the data collected (*cf.*, Krozser and Hjermsstad 1995; Montana SHPO 2002; also see Section 3.1.2.3). This section outlines some of the most commonly recorded attributes for stone circles sites and ones that were considered for this study.

Ring Size

As stones were placed directly on the surface, the visibility of stone circle sites is not dependent on site size or the amount of cultural material present; even briefly occupied sites can remain highly visible (Krozser and Hjermsstad 1995). Therefore, ring size is an attribute that can be easily documented, providing insight into the size of individual dwellings, and is one of the

most commonly documented attributes for stone circle sites (Quigg and Brumley 1984). Diameters are typically measured in cardinal directions (north-south and east-west) by chain and compass and in some cases the diameters for ordinal directions are documented (Krozser and Hjermsstad 1995). Some researchers also record both the interior and exterior diameters of ring features (Montana SHPO 2002).

Rings considered to be related to habitation structures typically range from 2.5 to 10 meters in diameter while rings with a diameter in excess of 10 m are considered to be ceremonial (Brace 2005; Davis 1983b). Finnigan (1980) reported habitation circles on the Northern Plains to range from 2.5 m to 7.4 m in diameter with an average diameter of 4.6 m (similar averages have been calculated by Brumley and Dau [1988] and Roll [1981]). In addition to dwellings, rings found at habitation sites which fall into this size range may also include death lodges, sweat lodges, menstrual lodges, and birthing lodges (Graspointner 1980).

While the intended use of a ring undoubtedly played a role in its size, researchers have postulated that the size of rings associated with habitation structures also changed over time. Ewers (1955:307-308) and Kehoe (1960:462) were the first to suggest that ring size increased after the introduction of the horse; prior to the use of horses, lodge size would have been limited by the maximum weight of lodge hide covers that could be transported by dog travois (~75 lbs, 6-7 buffalo hides for rings ~3 m in diameter). They suggested that the introduction of the horse permitted the transportation of material associated with larger lodges; tipi ring diameters in excess of 4 m were considered to represent protocontact/historic occupation. However, subsequent research has suggested that this was not necessarily the case.

Based on his work in Alberta, Quigg (1979, 1981) reported very little change in average ring size over time between approximately the Middle Precontact period (7,500 yr BP) to post-contact (AD 1850) (see Figure 3-1), with ring diameter ranging from 4.1 m to 6.3 m during the Middle Precontact period, 3.4 m to 7.0 m during the Late Precontact period, and 4.4 m to 6.0 m during the early historic period. Baldwin (1995) also found that ring diameter on the Northern Plains remained relatively consistent between the Late Precontact and Historic periods, noting an increase in size during the Besant Phase which reverted back to smaller rings during the Avonlea Phase. These data suggest that ring size was not particularly influenced by the introduction and use of the horse but instead may reflect the number of individuals occupying the dwellings, social status, wealth, and/or regional or cultural variation.

Stone Count, Size, Weight, and Buried Depth

Stone count per ring and/or per octant is another commonly recorded attribute. These data, namely the density and arrangement of wall stones, can provide insight regarding the season of occupation (Deaver 1989) and the anchoring strategy that was employed (Finnigan 1982). Placement and density of stones has been suggested to have been a response to the intensity and direction of prevailing winds; in warmer seasons winds tend to be less intense and dwellings required ventilation while during the winter months winds are more intense and inclement conditions required more weight and greater stone density in ring walls for stability and draft-free quarters. A greater density of stones on one side of the ring has been suggested to indicate the direction from which the wind was blowing (Deaver 1989; Finnigan 1981; 1982; see Figure 3.1-1).

Stone count and density are therefore attributes that contribute data to the overall understanding of stone circles sites (Finnigan 1981, 1982). Stone count remains one of the most commonly documented attribute for stone circle sites. At an inventory level for instance, the Montana State Historic Preservation Office requires the documentation of the number of visible stones that can be attributed to an individual ring, while at the testing level archaeologists are required to document the count of rocks per octant and the length of one representative stone per octant (Montana SHPO 2002).

The size and weight of stones also undoubtedly played a key role in securing lodge coverings, however, these attributes are variably documented. As noted above, glacial drift deposits on the prairie surface were an easily accessible resource on the Northern Plains, often containing boulders and cobbles of appropriate size to be used as weights around a dwelling. Brace (2005:5) suggests that individual boulders used in stone features were typically "bread loaf-sized", ranging from approximately 0.15 to 0.50 cubic meters (m^3), with an average size of approximately 0.30 m^3 . In addition to gleaning information about the seasonality of occupation and wind direction, data pertaining to the size, weight, and density of stones can aid in the determination of ring contemporaneity (Deaver 1989; Finnigan 1982; Quigg 1986).

Despite this, stone size and weight is not consistently recorded by all researchers (Krozser and Hjermsstad 1995). In fact, Quigg and Brumley (1984) and Krozser and Hjermsstad (1995) note that stone weight (both individual and cumulative per ring) is an attribute seldom recorded by researchers and when it is collected it is often presented in tabular form without any

analysis. Krozser and Hjermsstad (1995) go on to state that the collection of stone weight is labour intensive and not a cost effective attribute to document. Instead, they suggest that ring rock counts and a sample of ring rock depth would serve the same purpose for a fraction of the effort. This approach is bolstered by Hanna (1991) who found a strong statistical correlation between depth and weight of ring rocks. Still other researchers simply recorded a subjective estimate of buried rock depth based loosely on the percentage of rock exposed (even though local erosion and depositional processes are likely to influence stone visibility).

Wall Gaps/Entrances, Wall Courses

Few archaeological studies prior to 1995 documented the location of gaps or possible doorways/entrances in ring walls (Krozser and Hjermsstad 1995). However, with the move toward more holistic landscape approaches, some researchers have started to place more emphasis on the documentation of gaps in ring walls. The Montana SHPO (2002) requires the documentation of the presence or absence of gaps (defined as a void between stones which exceed roughly 50 cm and make up less than 90° of the stone circle) and their cardinal orientation in an effort to document possible door locations. Some ethnographic evidence indicates a preference for a doorway to face to the east toward the rising sun (*cf.*, Campbell 1927). However, researchers have found that the sun does not rise at the cardinal direction of east in parts of the Northern Plains and instead rises more toward the southeast. In such cases doorways may simply face the direction of the rising sun (Brumley 1983; Hungrywolf 1972; Kehoe 1960).

Doorway location may also reflect more practical purposes such as facing away from prevailing winds, preferred viewscapes or directionality to important landscape features, placement of hearths or other features within or adjacent to the ring, or facing toward the camp interior (Banks and Snortland 1995; Day and Eighmy 1998; Long 2011; Moore 1996; Oetelaar 2000; Quigg and Brumley 1984). Despite increased efforts to document wall gaps, they can be difficult to observe and are not always evident (Kehoe 1960:444). Over the passage of time, the integrity of ring walls may have been influenced by past disturbances (*i.e.*, initial breaking of camp, cattle, vehicles, etc.) or sedimentation which can bury some or all of the stones creating a false impression of a doorway (Dasovich 1998). In addition, some dwellings were built with an

elevated door to deter animal entry and improve the rain seal and therefore would not have had or needed a gap in the wall (Adams 1983:8; Kehoe 1983:336; see Figure 3.1-1).

Also pertinent to the completeness of ring walls are the number of courses of rocks, typically being single or double walls. While this is an attribute which is not consistently recorded (Krozser and Hjermstad 1995), some researchers, such as Kehoe (1958) and Laubin and Laubin (1977) suggest that a double row of rocks may indicate a dwelling which had an inner liner which would have been pegged or weighed down by rocks and/or household goods. An inner liner had several purposes: it reduced wind entering along the bottom edges of the outer covering, protected from rain running down the poles during inclement weather, increased ventilation - warm air rising from the inside of the dwelling drew cold air up between the liner and outer covering and out the top of the tipi creating an ideal draft for fire smoke and a pocket of air which insulated the dwelling, helping to keep it warm in the winter and cool in the summer (Hungrywolf 2006; Laubin and Laubin 1977). Interestingly, Laubin and Laubin (1977) note that an inner lining was often not used when people were on the move, as it was too time consuming to hang, but would have been necessary during extended periods at a single place. As such, single rows of rocks may suggest short-term occupation.

3.1.1.3 Temporal and Cultural Associations

A major challenge for archaeologists has been assessing the temporal and cultural affiliations of stone circle sites. Because stone circle sites are almost always surface sites, taphonomic processes can adversely affect site deposits. Stone circle sites often occur in areas of low sedimentation with cultural deposits remaining relatively close to the surface. This can result in poor preservation of cultural materials which remain exposed on the surface for long periods of time; bone and dateable hearth deposits are seldom preserved (Schiffer 1987). While lithic material will preserve under such conditions, stone circle sites have been noted for their general lack of diagnostic artifacts (*cf.*, Forbis 1970). Poor deposition can also result in a lack of stratigraphic data, limiting site interpretation and masking repeated occupation.

Due to typically minimal deposition, lack of vertical differentiation among separate stone feature building events, and often few diagnostic or chronometric data, researchers are left to grapple with how to identify episodes of site reoccupation through time. Minimal amounts of sedimentation (often no more than 5-15 cm of total deposition), which is typical at stone circle

sites, means that in the case of recurring occupations at a single location, materials from discrete occupations are mixed, forcing the archaeologist to collapse all occupations into a single cultural level (Deaver 1989; Dooley 2002). While some excavation data suggest that many medium ring sites (5-26 rings) and almost all large ring sites (greater than 26 rings) likely saw several episodes of reuse, such evidence can be difficult to discern (*cf.*, Davis 1983b; Deaver 1983, 1989; Deaver and Deaver 1987; Fredlund et al. 1985; Gragson 1983; Quigg 1986), though is sometimes discernible (Stuart 1990).

Stone robbing, instances where stones from abandoned rings are moved/reused during subsequent occupation events, can muddle the archaeological record at stone circle sites. Recycled stone rings from earlier occupations leave little evidence of the original lodge location, however, often only the closest parts of a ring were robbed, leaving some evidence of the previous occupation (Deaver 1989). While some interpretation and suggestion of site reuse can be made by documenting instances of robbed rings, to definitively identify occupation events, relative ages of each feature must be supported by radiocarbon dates or diagnostic artifacts (Deaver 1989; see also Section 3.1.2.3).

Because of the difficulty archaeologists often face determining when stone circle sites were occupied, assigning cultural associations is equally difficult. Until the mid-1960s, stone circle sites were generally thought to be a relatively late manifestation. Mulloy (1965) and Mulloy and Steege (1967) presented evidence from Wyoming that dated rings to the Middle Precontact period (Figures 3-1 and 3.1-2: Mulloy Sites - 48PI21, 23, 24, 29). Soon after, the oldest documented and securely dated stone circle site, dating to the late Early Precontact period (approximately 8,600 years BP) was found at the Hell Gap site in eastern Wyoming (Figure 3.1-2) (Irwin-Williams et al. 1973; Larson et al. 2009), though few sites of comparable age have been found (Kornfeld et al. 2010). While it appears that the use of stone circles increased during the Middle Precontact period, the majority of ring sites on the Northern Plains date to the Late Precontact and Protocontact periods (Figure 3-1; Kornfeld et al. 2010; Scheiber 1993). Interestingly, Deaver (1989) notes that most stone circles found in Montana and North Dakota were constructed during an 800-year period between 800 to 1,600 years BP and that very few rings predate 2,000 years BP, with the majority of rings being associated with the Besant culture period (2,000 to 1,100 years BP) (Deaver 1989).

3.1.2 History of Stone Circle Investigations

3.1.2.1 Early Accounts

Stone circle sites found on the Northern Plains have been of interest and documented since the early years of European exploration in North America. Some of the earliest accounts of stone circle sites on the Northern Plains were recorded in ethnographic narratives and travel journals (Campbell 1927; Dawson 1875; Grinnell 1892; Hind 1860; Lewis 1889). In the narrative describing his journey through the Moose Jaw region during the Assiniboine and Saskatchewan Expedition of 1858, Hind noted:

Immediately on the banks of the Qu'appelle Valley near the "Round Hill" opposite Moose Jaw Forks, are the remains of ancient encampments, where the Plain Crees, in the day of their power and pride, had erected large skin tents, and strengthened them with rings of stones placed round the base. These circular remains were twenty-five feet [7.6 m] in diameter, the stones or boulders being about one foot in circumference. They wore the aspect of great antiquity, being partially covered with soil and grass [Hind 1860: 338, vol. 1].

Palliser also made observations about the sizes of lodges his party encountered during the Palliser Expedition of western Canada between 1857 and 1860. Upon encountering a large camp of some 400 tents near the Red Deer River, he noted:

The Blackfeet tents are not only much larger than those of the Crees, but much better provided with internal accommodation, such as leather curtains to protect them from draughts...the tents of the chiefs are about 20 or 22 feet [6 to 6.7 m] in diameter; but there are some medium [size] tents, or tents where the chiefs assemble in council, that are nearly 30 feet [9 m] in diameter...[Spry 1995:230].

These and other narratives and journals of explorers who travelled through the Northern Plains between the 1600s and 1800s often note the presence of stone rings, provide some details relating to the general position and nature of stone circle sites, and impart eye witness accounts of aboriginal camps.

3.1.2.2 Early Studies - 1930s to 1960s

The late 1930s and 1940s brought about the first archaeological studies of stone circle sites on the Northern Plains (*cf.*, Bliss 1949; Mulloy 1952; Wedel 1948). Work carried out as part of the River Basin Surveys (RBS) played an influential role in the developing field of North American archaeology. The RBS were part of a large-scale program of archaeological investigations that took place along the Missouri River drainage after the issuance of the *Flood Control Act of 1944* which would provided flood control, irrigation, and hydroelectric power (Jennings 1985). Many of the resulting reports made observations of stone circle sites but few provided details regarding individual features (Davis 1983b). It was during this work that the notion of placing an evaluated order of relative worth on archaeological sites was formed; stone circle sites were often judged as least important compared with other site types due to the lack of observed cultural materials and shallowness of deposits (Davis 1983b).

It was also during this time that debate began to rise about the purpose of stone circle features. Mulloy's (1952) publication is a prime example of the hesitation that some archaeologists at the time had in classifying stone circles as evidence of past placement of hide-covered lodges. However, Kehoe's (1960) seminal publication on stone rings in Montana and Alberta summarized earlier work and provided a comprehensive analysis of ethnographic, historical, and archaeological evidence to determine the purpose of stone circles. His critique of Mulloy's publication was pointed and left little doubt about the function of stone circle features. In 1961, Wedel (1961) and Malouf (1961) published works that agreed with most of Kehoe's findings but argued that while most stone rings were indeed "tipi rings" used for weighing down the edges of hide lodges, some were not and served different purposes, thus opening avenues for further investigation.

3.1.2.3 Stone Circle Research Boom Years - 1970s to 2000s

The latter part of the 1960s and the 1970s brought about a major shift in North American archaeology. "New Archaeology" placed a strong emphasis on systems theory and developing universal scientific laws to explain human behaviour (*cf.*, Binford 1962; Dunnell 1982). However, the "New Archaeology" movement had little effect on stone feature research on the Northern Plains (Dooley 2002). Instead, the establishment of heritage legislation in Alberta (est.

1973; *Historical Resources Act* 2000), Saskatchewan (est. 1980; *Heritage Properties Act* 1980), and in the United States (est. 1966; *National Historic Preservation Act* 1966) drove much of the work behind the documentation and examination of stone circle sites across the Northern Plains (Burley 1990; Davis 1983b).

In addition to the establishment of heritage legislation across the Northern Plains, the late 1970s and early 1980s was a period of florescence for stone circle research. It was during the 1970s that several publications were produced which moved beyond simple descriptive reports to include quantitative data for stone circle sites (*cf.*, Flayharty and Morris 1974; Schneider and Treat 1974). Also, beginning during the 1970s and continuing into the 1980s and 1990s, more effort was being spent on developing methods for documenting stone circle sites in more efficient and cost-effective ways.

The "Tipi-Quik" recording system developed by Smith (1974), and modified by Dau (1981), was a major methodological innovation which allowed for the efficient and accurate mapping of stone rings, and is a system still used today. Other researchers explored the use of photogrammetric methods for documenting stone features, including the use of photoboos and low level aerial photography (*cf.*, Brumley and Dau 1988; Davis and Carroll 1981; Deaver and Morter 1981). While photogrammetric methods did produce significant results and showed real promise for documenting surface features, these methods remained largely unused in Northern Plains archaeology due to the extra time and expense needed to employ them (Dooley 2002; see Section 3.1.2.4 for current photogrammetric methods). Researchers were also exploring ways to glean subsurface information from sites without extensive excavation, such as the use of auger/probe testing and limited excavations (*cf.*, Fredlund et al. 1985).

It was also during this period that a number of conferences and symposiums were held in an effort to move research directions forward, establish some level of continuity with regards to the type of data being collected, and discuss methods for recording and testing stone circle sites. These conferences resulted in important publications which are still consulted today. The Eleventh Annual Chacmool conference hosted by the University of Calgary in 1978 produced *Megaliths to Medicine Wheels: Boulder Structures in Archaeology* (Wilson et al. 1981). This was followed by a symposium in 1981 at the Plains Anthropological Conference in Bismark, North Dakota resulting in *From Microcosm to Macrocosm: Advances in Tipi Ring Investigations and Interpretation* (Davis 1983a).

In addition, numerous researchers working across the Northern Plains began to publish the results of new methods being employed and findings from projects both big and small. Major publications from this period with a Canadian focus include Finnigan's (1982) work at a large stone circle site in southeastern Alberta (EdOp-1) and Brumley and Dau's (1988) work on 102 sites in the Forty Mile Coulee in southeastern Alberta (Figure 3.1-2), among many others. In addition, methods for recording and testing stone feature sites in North Dakota were published by Fredlund et al. (1985) and the State Historical Society of North Dakota published a review of current literature and methods (Quigg and Brumley 1984).

Work on stone circle sites during the 1990s and early 2000s followed similar research trends as seen in earlier decades. Additional research directions also emerged during this period which focused on better understanding the division of space and recognizing gendered areas within individual dwellings and considerations of social meaning based on spatial distributions within stone circles, as well as an overall focus on spatial patterning across larger geographic areas (*cf.*, Forner 2005; Oetelaar 2000; Peterson 1997; Wilson 1995).

Some challenges also emerged while trying to explore these new research directions. One of the greatest challenges involved difficulties in comparing stone circle site data which had been recorded in very different ways. Burley (1990) expressed doubts about the validity of some attribute-driven analysis and highlighted the need for standardization of data collection. In a response to these challenges, archaeologists from across the Northern Plains met once again in 1993 to discuss the treatment of stone circle sites. The workshop explored current practices with regards to stone circle site impact assessments, mitigation (including feature data collection and excavation), data collection and reporting standards, and future goals, resulting in the publication of *Stone Circle Site Treatment Review and Workshop: Final Report* (Krozser and Hjermstad 1995). The Montana State Historic Preservation Office (SHPO) also published *Recordation Standards and Evaluation Guidelines for Stone Circle Sites* in a response to calls by consultants and agencies for a "predictably acceptable level of standard site recordation for compliance purposes" (Montana SHPO 2002:3).

3.1.2.4 Current Investigation Strategies and New Research Directions

While the methods of investigating and documenting stone circle sites developed in the 1970s, 1980s, and 1990s are still used today (*i.e.*, tipi-quick recording methods and attribute

documentation), they remain time consuming and labour intensive. Consequently, researchers continue to seek new ways to economically and efficiently document stone circle sites.

With the advent of remote sensing technologies and their relative ease of use and affordability, researchers are now starting to employ them during investigations of stone circle sites. Kvamme (2008) describes remote sensing as techniques that acquire information about a subject through indirect means. In archaeology, such techniques typically include ground-penetrating radar (GPR), magnetometry, and aerial/satellite imagery which have allowed researchers to look below the surface at a site to assist in identifying the location and nature of buried archaeological features (Kvamme 2006). These methods have allowed for targeted testing and reduced the level of impacts to sites during subsurface investigations. Features that have been discovered as a result of GPR and magnetometry include buried rings, hearths, and pits (*cf.*, Archeo-Physics 2012; Gibson 1982; Jones and Munson 2005; Norris 2010; Scheiber and Finley 2010; Sheriff 2013).

The ever-improving precision of Global Position Systems (GPS; such as Garmin and Trimble units) have also allowed for effective digital field data acquisition (Ainsworth and Thomason 2003), the ability to accurately record the geographic locations of individual stones, and the capability to easily create comprehensive maps of stone circle sites. In addition, some GPS devices (such as the Trimble Nomad) can accommodate the installation of mobile software which allows the field archaeologist to collect spatial data while entering details about the features being recorded. The use of digital total stations has also provided a method for quickly and accurately documenting three-dimensional provenience during site documentation and excavation, alleviating the time-consuming post-field effort required to enter data for later analysis (Vivian and Reeves 2006; Ziebart et al. 2002).

The relative ease of use and accessibility of geographic information systems (GIS) software has also given archaeologists an improved method for processing and analyzing spatial data collected at archaeological sites (Conolly and Lake 2006; Huggett 2015). This has been particularly useful for researchers investigating spatial patterning and those considering more holistic landscape approaches. The collection of robust elevation data and incorporation of digital elevation models (DEM) and LiDAR (Light Detection and Ranging) data, which offer high resolution elevation information, has assisted in our ability to evaluate topographic expressions of past human activities within cultural landscapes and provide the data needed to

carry out GIS-based studies of viewsheds and visibility (Conolly and Lake 2006; Kvamme et al. 2006; Vivian and Reeves 2006).

While photogrammetry had been previously explored but subsequently dismissed by researchers on the Northern Plains (see Section 3.1.2.3), with ever-improving digital hardware, processing abilities, and affordability, photogrammetry is a tool which continues to hold real promise in stone circle investigations. Low-level photography captured by cameras affixed to kites/weather balloons or mobile photographic booms (many of which can extend up to 10 m in length) can now be operated remotely via mobile phone devices or other technology, providing detailed photographs of site elements and accurate planview photos of features which are typically difficult to photograph (Anderson 2001; Hanna et al. 2009; Murray et al. 2013).

In addition, the evaluation of aerial imagery, which has long been a tool used by archaeologists, is becoming a much more common technique for data capture and site documentation with the advent of affordable drones/unmanned aerial vehicles (UAV) which have the capability to take and store photographs themselves, or can have cameras attached. Captured images can be georeferenced and assigned map coordinates using GIS software, providing insight about local terrain features (including surface features such as stone circles and cairns) and land cover (Giardino and Haley 2006). Although weather conditions can play a factor in the success of airborne data capture and the use of personal UAVs is coming under policy/permitting review by many jurisdictions (*cf.*, Transport Canada 2012), it is a method that is continuing to gain momentum for archaeological site documentation.

Perhaps one of the primary concerns which continues to plague many stone circle researchers has been a call for more radiometric dating of stone circles sites (Krozer and Hjerstad 1995). Despite this, the fact remains that recovering datable archaeological organics and/or diagnostic artifacts can be unpredictable at best and often requires extensive excavation. Burley (1990) expressed frustration about this problem noting that less than 1.5% of the documented stone circle sites in Alberta at the time had been dated by radiocarbon analysis, obsidian hydration, or cultural diagnostics. Regrettably, the situation appears to still plague archaeologists today. Table 3.1-1 summarizes the number of stone circle sites which have been documented in Saskatchewan, Alberta, and Montana and the low percentage of those sites which have been subject to radiocarbon analysis (see also Dasovich [1998:219] for estimates of dated stone circle sites in South Dakota and Scheiber [1993:46] for Wyoming).

Table 3.1-1. Stone circle sites dated by radiocarbon analysis on the Northern Plains*.

Province/State	Documented Sites Containing Stone Circles	Stone Circle Sites Dated by C ¹⁴	Percentage of Stone Circle Sites Dated by C ¹⁴
Saskatchewan	5,839	15 ^{**}	0.26%
Alberta	8,331	74	0.89%
Montana	8,174	9	0.11%

*Data provided by: Nathan Friesen and Lorna Dmyterko of the Saskatchewan Heritage Branch, Darryl Bereziuk and Courtney Lakevold of the Archaeological Survey of Alberta, and Stan Wilmoth and Damon Murdo of the Montana State Historic Preservation Office. Current as of May 2016. **This figure does not include sites investigated for this thesis.

To improve the success of accurately dating stone circle sites without the need to recover diagnostic artifacts or carry out extensive excavations, some researchers are employing magnetometry (discussed above) to target hearths and areas of burning at sites in an effort to extract datable organics (Norris 2010; see also Chapter 5). While recent advances in AMS dating has allowed for the submission of very small samples, the scarcity of datable material due to hearth absence or degradation over time still continues to be a problem. In an attempt to overcome these difficulties, researchers are exploring other dating methods, such as optically stimulated luminescence (OSL) and lichenometrics, when traditional radiocarbon analysis is not an option (Dasovich 1998). Although these methods offer opportunities to increase the number of dated stone circles, they typically do not offer the chronological resolution necessary to establish contemporaneity of features within a site (Oetelaar 2004).

Feathers (2012) explored the use of OSL dating on five stone circle sites in Montana and Wyoming which showed promising results albeit with some inconsistencies. Despite this, he felt that "the chronological information provided, even if imprecise, marks an improvement over the current lack of chronological knowledge [at stone circle sites]" (Feathers 2012:404). As such, for sites that do not produce organics that can be analyzed by conventional radiocarbon dating, OSL dating may be a means to identify an age range into which site occupation falls, although more research on the use of OSL on shallow stone circle sites is warranted.

Although lichenometry has been successful in dating surface features in other parts of the world (Benedict 2009), it has been largely dismissed by researchers investigating stone circle features on the Northern Plains (Dasovich 1998). Research on stone circle sites that has attempted to utilize lichenometry has largely resulted in inconclusive findings (Dooley 2002; Vickers and Hastings 2005; Wilson 1983). The lack of regional species-specific growth data required to establish lichen age and the inability to know if stones used in the construction of stone circles where previously lichen-free has largely contributed to the lack of conclusive

results (Benedict 2009). Without the development of regional species-specific lichen growth curves, it is likely that this method will remain on the periphery of dating techniques used in stone circle investigations.

3.2 Regional Archaeology

Saskatchewan has had a long history in documentation of and collection from archaeological sites. Collections made by generations of landowners provided some of the first glimpses of the rich history of the province (Riehl-Fitzsimmons et al. 2013). This is true for the region around Little Manitou Lake; archaeological sites in the area have been documented as a result of private collections, work carried out by avocational archaeologists, and through the Collection Registry Program which was undertaken by the Royal Saskatchewan Museum in the mid-1980s (Conaty et al. 1988; Viscount and Area History Book Committee 1985). Prior to the 1980s, cultural affiliation determinations of sites documented in the region were based on comparing artifacts in private collections to established tool typologies. These cultural affiliations extend the prehistory of the area back to the early Precontact period, based on the presence of Cody Complex materials collected from a number of sites (Figure 3-1) (Dyck 1983; Saskatchewan Heritage Branch data for NTS Mapsheet 72P).

In recent years a handful of stone circle sites near the parkland-grassland interface of central Saskatchewan have been subject to detailed investigations. Three archaeological sites within Wanuskewin Heritage Park, north of Saskatoon, contain stone circles (Figure 3.2-1, Wanuskewin Sites - FbNp-7, FbNp-10, and FbNp-17). One of nine rings at the Sunburn Site (FbNp-7) was excavated by Walker (1983); no diagnostic artifacts were found and the site remains undated. Excavations at the Amisk Site (FbNp-17) revealed a buried ring dated to the Prairie Side-notched/Avonlea transition period (905 ± 155 years BP/ca. AD 1045) (Amundson 1986; Walker 1988). Evidence of another possible buried ring, likely from the Besant period, was also discovered in the upper levels of the Red Tail Site (FbNp-10) (Ramsay 1993).

Closer to the study area, the Coffin Site (EINk-1) located 25.5 km north-northwest of Little Manitou Lake and east of the town of Colonsay, SK, was the focus of field school excavations in 1982 and 1983 by the University of Saskatchewan (Figure 3.2-1). During the field program, 20 rings and a stone cairn were mapped, of which three rings were partially excavated, seven rings fully excavated, the cairn excavated, and 96 small shovel tests conducted outside of

ring features (Linnamae 1983, 1995). Few cultural materials were recovered. While a point, recovered from the surface beside a ring, was originally thought to reflect an Oxbow affiliation for the ring site, Linnamae (1995:39-40) notes that the recovered point was broken basally and could not be identified with certainty to a particular side-notched type. Subsequent radiocarbon dating of bone recovered from a hearth suggested an age of 1,555 years BP (± 85), placing site occupation during either Besant or Avonlea times (Linnamae 1995).

Two other sites in the region are worth mention: ElNi-1 and ElNi-2 (together known as the Farago Site) are located south of Plunkett, SK approximately 18.7 km northeast of the western end of Little Manitou Lake (or 12.6 km from the closest shoreline) (Figure 3.2-1). The sites, which were recorded as artifact scatters in adjacent quarter sections and partially excavated in 1969 by Saskatchewan Museum of Natural History personnel (now the Royal Saskatchewan Museum), largely contain Late Precontact period points (both Prairie and Plains Side-notched), lithics of pebble cherts, Knife River flint, silicified peat, and fused shale and pottery from the Old Women's and Mortlach phases (Figure 3-1; Malainey 1991; Rescan 2013; Viscount and Area History Book Committee 1985). Unfortunately, because the material from this site was recovered from ploughed fields, *in situ* stratigraphic data are not available nor are data available pertaining to site features. In addition, a detailed study of the extensive artifact collection from this site has not been carried out or published, with the exception of Mary Malainey's evaluation of Mortlach pottery held at the museum (1991).

Within the study area, several detailed archaeological investigations have been conducted. In 1984, a Heritage Resource Impact Assessment (HRIA) was completed for the Saskatchewan Power Corporation Rural Gas Line which extends between the villages of Young and Watrous (Kenny 1985). This line runs through one of the archaeological sites investigated during this study (EkNk-3); during the 1984 assessment 10 stone circles were recorded (see Figure 3.2-1 and Chapter 5). In 2006, detailed surveys were conducted by the Saskatchewan Archaeological Society (SAS) around the large glacial erratic situated to the southwest of Little Manitou Lake at EkNk-4 (known locally as the Young Erratic; Figure 3.2-1 and Chapter 6) which resulted in the documentation of stone circles, cairns, and rock alignments (Cyr-Steenkamp et al. 2010). Between 2010 and 2012, systematic surveys were carried out around the western half of Little Manitou Lake for a proposed potash project, resulting in the documentation of 119 archaeological sites (Figure 3.2-1 and Section 3.2.1; Rescan 2011, 2012b, 2013).

3.2.1 Archaeological Sites Within the Study Area

Prior to this study, there were 93 previously documented precontact archaeological sites within the study area illustrated in Figure 3.2-1, 51 of which contain features suggesting residential use (*i.e.* stone circles). One site (EkNj-32) has been subject to subsurface testing and two sites (EkNj-38 and EkNj-67 - described below) have produced artifacts that allow for some cultural associations. These sites are situated on land once owned by the Farago family, who have lived south of the village of Plunkett since 1906 and have accrued a large collection of artifacts from the area. Although there are some small scrapers and hammerstones, the majority of the collection consists of projectile points from Avonlea, Besant, Prairie Side-notched, and Plains Side-notched complexes, and several McKean lanceolate projectile points (Figure 3-1; Rescan 2012b, 2013). The collection has been described as one of the largest collections of precontact artifacts in Canada containing "arrowheads, flint, medicine stones, peace pipes, pemmican beads, wampum, scrapers, axes and pottery too numerous to mention...found only in certain areas of the farm and were come upon accidentally" (Viscount and Area History Committee 1985:321). It is likely that some of the Farago private collection contains material from ElNi-1 and ElNi-2 (discussed previously) and EkNj-38 and EkNj-67 since the family owned the properties on which these sites are situated and collected from these areas.

Archaeological site EkNj-32 is a stone circle site situated 9.5 km north-northeast of the western end of Little Manitou Lake (or 8.2 km from the closest shoreline). It consists of 20 stone circles and a circular depression. Subsurface testing yielded two point fragments and one biface fragment (none could be attributed to a particular culture period), lithic debitage, ochre, and bone (likely bison) (Rescan 2013).

Archaeological site EkNj-38 is an Early Precontact site containing Cody Complex material and is the oldest documented site in the Little Manitou Lake region. A single basal fragment of a lanceolate point (possibly an Eden point) was recovered from the surface (Rescan 2012b; ARMS records). The site is situated 9.5 km northeast of the western end of Little Manitou Lake (or 3.5 km from the closest shoreline). As noted above, the land on which this site is situated was once owned by the Farago family and it is likely that artifacts from this site were previously collected.

Archaeological site EkNj-67 is a lithic reduction and kill site located 9.8 km from the western end of the lake (or 3.9 km from the closest shoreline). Fragmented bone has been

observed during ploughing in two discrete areas of the site and a large number of artifacts have been collected by the Farago family (Rescan 2013).

Other precontact sites within the study area have not produced culturally or chronologically diagnostic material. A total of 87 sites have been documented as precontact based on the presence of lithic artifacts (debitage) or features which suggest precontact occupation (*i.e.*, stone circles). Eight of these sites have been classified as Sites of Special Nature (SSN) due to the presence of ceremonial features, including medicine wheels, rock alignments and vision quest features (including EkNk-4 noted above; see Chapter 6). Four other sites have been classified as "unknown" as data are not available to place these sites temporally.

3.3 Regional Historical Background

Dominion Land Surveys were conducted in the region in the 1880s oriented toward the relocation of aboriginal communities onto reserves in order to provide land for European settlers, who were starting to arrive in Saskatchewan (McCrary 2001). Surveys carried out in the Little Manitou Lake region showed both areas of arable land and areas expected to be unarable due to the presence of salt marshes and alkaline lakes (Wheeler 1884). Donkin (1973) wrote of the salt plains to the west of Big Quill Lake and reported a spring between Little Manitou Lake and Big Quill Lake which provided the only drinking water within 45 miles (~72 km), despite its being "impregnated with iron" (Donkin 1973:173 and enclosed map). Even with reports of potentially poor soil quality and the paucity of fresh surface water, a few settlers began to arrive in the region by 1903, followed by a substantial increase in 1904. By 1906 most of the available homestead land was taken (Watrous History Book Society 1983).

The arrival of the railway further increased immigration to the region, with the railway towns of Young, Viscount, and Plunkett serving as centres for the surrounding farming communities (Viscount and Area History Book Committee 1985). To the south of the study area, through the Venn-Watrous district, the Grand Trunk Pacific railway was completed by 1907, joining the existing north-south Grand Trunk Pacific line at Xena. To the north, the CPR connected the towns of Lanigan, Guernsey, and Plunkett. The population in the region continued to grow until the 1930s when the combination of hard economic times and drought of the Great Depression / Dirty Thirties caused many to abandon their homesteads.

Local histories recount stories told by homesteaders of aboriginal populations who would bring their sick and injured to the lake for treatment: sweat lodges were built along the shores for those with rheumatism, the injured would bathe and the sick would imbibe of its waters (Sproule 1984). An early settler, Josiah Martin, described an aboriginal camp established at the eastern end of the lake where people would gather to use the lake for medicinal purposes.

Little Manitou Lake is named for the Algonquian word meaning "mysterious being" or "great spirit" and became known as the "Lake of Healing Waters", "Lake of the Good Spirit", or *manitow-sākahikan* "God's Lake" (Christensen 2000; Schellenberg 1996). Aboriginal groups made annual pilgrimages to Little Manitou Lake constructing sweat lodges above a pit filled with hot stones over which water from the lake would be poured (Schellenberg 1996). Dan Kennedy, an Assiniboine of the Montmartre Reserve, recounted a legend about the lake:

...at the turn of the last century, several epidemics of small pox almost wiped out large tribes of the Crees...[Following a winter epidemic] the survivors headed for the Saskatchewan River. On their way, three of the braves became ill. When the tribe camped at Manitou Lake they were too weak to go any further. They built shelters for the sick men and left them while the tribe moved on...Crazed by fever, one of the men managed to crawl to the shore of the lake to appease his burning thirst and cool his fever. He lay along the shore and drank deeply of the waters, bathed his face and body, but was too weak to crawl back to the shelter. He lay there until the next morning...To his surprise he found that the fever had left him. He told the good news to his fellow companions and dragged them to the lakeshore. There he told them to drink and bathe themselves until they too were cured... A few days later they caught up with their fellow tribesmen who could not believe that these were the men they left behind. It took a lot of convincing to make them believe that they were not seeing the ghosts of the braves [Watrous Prairie Reflections 1983:236].

Like the aboriginal groups before them, the communities of Manitou Beach, Watrous, and Young have a long history of recreational and economic use of the Little Manitou Lake, dating back to the early 20th century when a booming tourist industry began to develop. Schellenberg (1996:3) wrote "...Healing waters brought health spas, massage parlours, and a host of practitioners of healing arts. Crowds gathered at Little Manitou to be healed. Legend has it that people would come on crutches and then leave them behind on a huge pile outside the clinics". Medical claims suggested that the mineral water was good for arthritis, joint problems, rheumatism, and skin conditions. Natural oils were extracted from the lake were used in hair

tonic and toothpaste. Local residents harvested the mineral salts which were sold to drugstores all over Saskatchewan, and until the early 1980s were bagged and shipped to Winnipeg for use in the curative and therapeutic waters of Uhlman's Health Spa (Last 1991).

The 1920s were boom times for the region with tourists coming by rail and car to enjoy the mineral waters (Schellenberg 1996). Three dancehalls were erected in the village of Manitou Beach, a number of swimming pools/spas were built, medical clinics were established, hotels were built to accommodate tourists visiting the area, and a booming cottage industry flourished. In the early 1930s, the provincial government undertook the construction of a luxury resort hotel as a relief project. The Park Chalet, situated in Manitou Lake Provincial Park, was constructed with locally sourced fieldstones by unemployed labourers. The chalet operated until the 1950s and was sold in 1956 to the Saskatchewan Society for Crippled Children, now operated as Camp Easter Seal. Danceland, one of the famous dancehalls, still remains (it is one of the few remaining dancehalls in Canada to tout a horsehair floor), as do a number of hotels, including the Manitou Springs Resort which has an attached mineral pool and spa.

The high salinity levels in the lake also supports a population of brine shrimp (*Artemia salina*) that were harvested from the lake (Persoone et al. 1980). Commercial harvest of brine shrimp began in Little Manitou Lake in 1961 by the Wardley Brine Shrimp Co. which processed and sold brine shrimp as fish food for the growing tropical fish market (Hammer 1985; Schellenberg 1996). At the time, the lake produced approximately 5,000,000 kg of shrimp each year but only a fraction was harvested; the maximum reported harvest was in 1967 with a harvest of 109,400 kg. Between 1963 and 1965 the value of the brine shrimp industry in Saskatchewan (which included operations at Little Manitou Lake and Chaplin Lake) varied between \$150,000 and \$450,000. The Little Manitou Lake operation ceased in 1972 due to the inability to effectively separate brine shrimp from the abundant filamentous green algae that is common in the lake. The old brine shrimp factory, which was originally converted from the Martin's Hotel, was finally torn down in 2013 (Schellenberg 1996; Watrous-Manitou Beach Heritage Centre 2012).

3.4 Chapter Summary

The information presented in this chapter provides an overview of approaches to investigating stone circle sites, including the regions where these sites are found, cultural and

temporal affiliations, and typical attributes researchers record in an effort to glean information from these silent markers of past habitation. It also summarizes research carried out at stone circle sites across the Northern Plains, illustrating the progression of research from the 1930s to today. Our present understanding of the archaeological setting of the Little Manitou Lake region is reviewed highlighting the sites that contribute most to our understandings of past occupation. Historic occupation in the region is also reviewed to better understand how the current landscape has been shaped. It is from this foundation that the current research builds.

Chapter 4

Research Methods

This chapter outlines the research methods employed for this study which were carried out under permit HRIA Type A 2015-063. The study area, described in Chapter 1 and illustrated in Figure 1-2, is focused on the western end of Little Manitou Lake east of the village of Young, SK.

4.1 Background Review

A review of pertinent background data was conducted for both the project area and surrounding region. Relevant documentary data included publically available ethnographies, historic accounts, academic papers and theses, archaeological studies, archaeological permit reports, and site forms obtained from ARMS. Topographic and biophysical information was reviewed, including NTS maps from 1:50,000 and 1:250,000, aerial photographs, and digital elevation model (DEM) data. Paleoenvironmental and geologic data pertaining to the Little Manitou Lake area was reviewed (see Chapter 2) as was the cultural and historical context for the area (see Chapter 3).

4.2 Field Methods

4.2.1 Site Selection and Survey

Ten archaeological sites at the western end of Little Manitou Lake were shortlisted as candidates for detailed subsurface investigations. The shortlist included sites that contained more than four stone circles and eliminated sites with less than four stone circles and those which contained ceremonial features (e.g., medicine wheels and sites of special nature). Landowners of quarter-sections containing selected archaeological sites were contacted to obtain permission to access properties. One additional site was added to the shortlist after consultation with a

landowner who had identified an as-yet unrecorded stone circle site approximately 400 m from a site already included in the shortlist.

Once permissions were obtained, sites were subject to pedestrian reconnaissance surveys to locate features, evaluate the current condition of the sites, identify any additional features which may have been previously unrecorded, and to determine if favourable conditions were present for magnetometry surveys (see Section 4.2.2). Site mapping and documentation was also carried out at the site which had not been previously recorded (now designated as EkNj-68; see Section 4.2.4 for additional information). Ultimately, three archaeological sites were selected for further investigation: EkNj-4, EkNj-68, and EkNk-3, due to favourable conditions for remote sensing and relatively good condition of located features.

Pedestrian surveys of the three selected sites were conducted along compass bearings with crew members spaced at 5 to 20 m intervals, depending upon terrain and visibility constraints. During traverses, ground surfaces were inspected for stone features, artifacts, depressions, and other evidence of past human occupation and use. Modern metal and iron objects (e.g., nails, barbed wire) that were observed on the surface during the pedestrian survey were removed prior to magnetometry surveys to eliminate potential sources of inaccurate readings.

4.2.2. Remote Sensing - Magnetometry and Magnetic Susceptibility

Two methods of remote sensing were carried out for this study and are described in this section. Magnetometry surveys were conducted prior to subsurface excavations and magnetic susceptibility evaluations were carried out on collected matrix samples post-excavation.

4.2.2.1. Magnetometry

Magnetometry surveys were conducted to assist in identifying areas appropriate for subsurface investigation. Such areas included locations where magnetic data suggested the presense of possible subsurface hearths or other cultural features (Gibson 1986). Field procedures for the use of the magnetometer were consistent with those outlined in Bevan and Smekalova (2013) and are summarized below.

At each site, 10 x 10 m grids were established around selected areas using non-metallic measuring tapes, pre-measured surveyors rope, and wooden stakes aligned to true north using a

compass with declination set to 9° 58' East (see Section 4.3.3 for further details regarding the survey grid). The corners of all magnetometry grids were recorded using a Garmin GPSmap 60cx (3-5 m, 95% accuracy with WAAS enabled; Garmin 2006). All crew members took care to check for and remove iron objects that could be carried in the fabric of clothing and shoes. The magnetometer employed was a FM256 Fluxgate Gradiometer manufactured by Geoscan Research (Figure 4.2-1), operated by Dr. Terrance Gibson of Western Heritage Services Ltd., which collected eight readings per linear metre with the instrument/magnetic sensor approximately 0.2 - 0.4 m above the ground surface and survey lines spaced 0.5 m apart. Beginning at the northwestern corner of each grid unit, each survey line was carried out on an east-west orientation. The unit of measurement collected by the magnetometer was nanotesla (nT) which is a measure of the magnitude of the earth's magnetic field. For fluxgate magnetometers this measure is the vertical gradient of the earth's magnetic field (the difference between the upper and lower sensors in the unit) (Bevan and Smekalova 2013).



Figure 4.2-1. FM256 Fluxgate Gradiometer and magnetic survey at EkNj-68.

Data from the magnetometry surveys were processed by Dr. Terrance Gibson of Western Heritage Services Ltd. using GeoPlot software (provided by Geoscan Research) and Surfer (Golden Software) to produce maps identifying locations of magnetic anomalies. Anomalies were mapped using blue for magnetic lows (negative) and red for magnetic highs (positive) and drawn using contour lines to illustrate areas of greatest lateral gradients. Gradient contour intervals presented on maps were shown as 1 nT intervals (see Chapter 5 and Appendix A). In some cases, intervals lower than -3/3 were suppressed for clarity as they represent ambient noise in the soil. Similarly, where intense anomalies were detected, intervals beyond -10/10 were

suppressed and shown as open holes on maps instead of being infilled (Dr. Terrance Gibson, personal communication 2016). These data were correlated with mapped rock locations (see Section 4.3.4) and used to identify areas most likely to contain hearth deposits for further investigation.

4.2.2.2. Magnetic Susceptibility

During excavation, matrix samples were collected from hearth features. Small subsamples of soil, ranging in size from 20 to 30 g, were removed from larger samples and were subject to post-excavation magnetic susceptibility evaluations. Dr. Terrance Gibson of Western Heritage carried out these evaluations by analyzing dried, weight-adjusted samples using a TerraPlus KT-10 susceptibility instrument to obtain bulk magnetic susceptibility evaluations. Readings were reported using SI units (see Glossary). These data were used to assist with the interpretation by identifying spikes or areas of elevated magnetic susceptibility. Small column samples were also collected from areas at each site where magnetic anomalies were absent in order to provide baseline magnetic susceptibility data for each site.

4.2.3 Evaluative Testing

Evaluative testing was carried out at each site at the areas identified during the magnetometry surveys. Excavation areas were organized into 10 m x 10 m grids tied into site datums. The corners of all excavation areas were recorded using a Garmin GPSmap 60cx. Each excavation area, from which excavation units were selected, was identified by a letter prefix and was further divided into 100 1 m x 1 m units, identified by a numerical suffix (Figure 4.2-2). As such, "unit A75" is the 75th unit within excavation area A. Where a 1 m x 1m unit was not fully excavated, the area was further classified by NE, SE, NW, or SW unit quadrants or E or W halves (N and S classifications were not required).

In most cases, the magnetometry grid were offset from the excavation baseline and associated excavation grids, in some cases being offset or separated by several metres to best capture areas which would be subject to magnetometry surveys. The magnetometry grids, also measuring 10 m x 10 m, were identified numerically according to the order in which they were surveyed. Maps illustrating the excavation areas and magnetometry grid areas are provided in Chapter 5 and Appendix A.

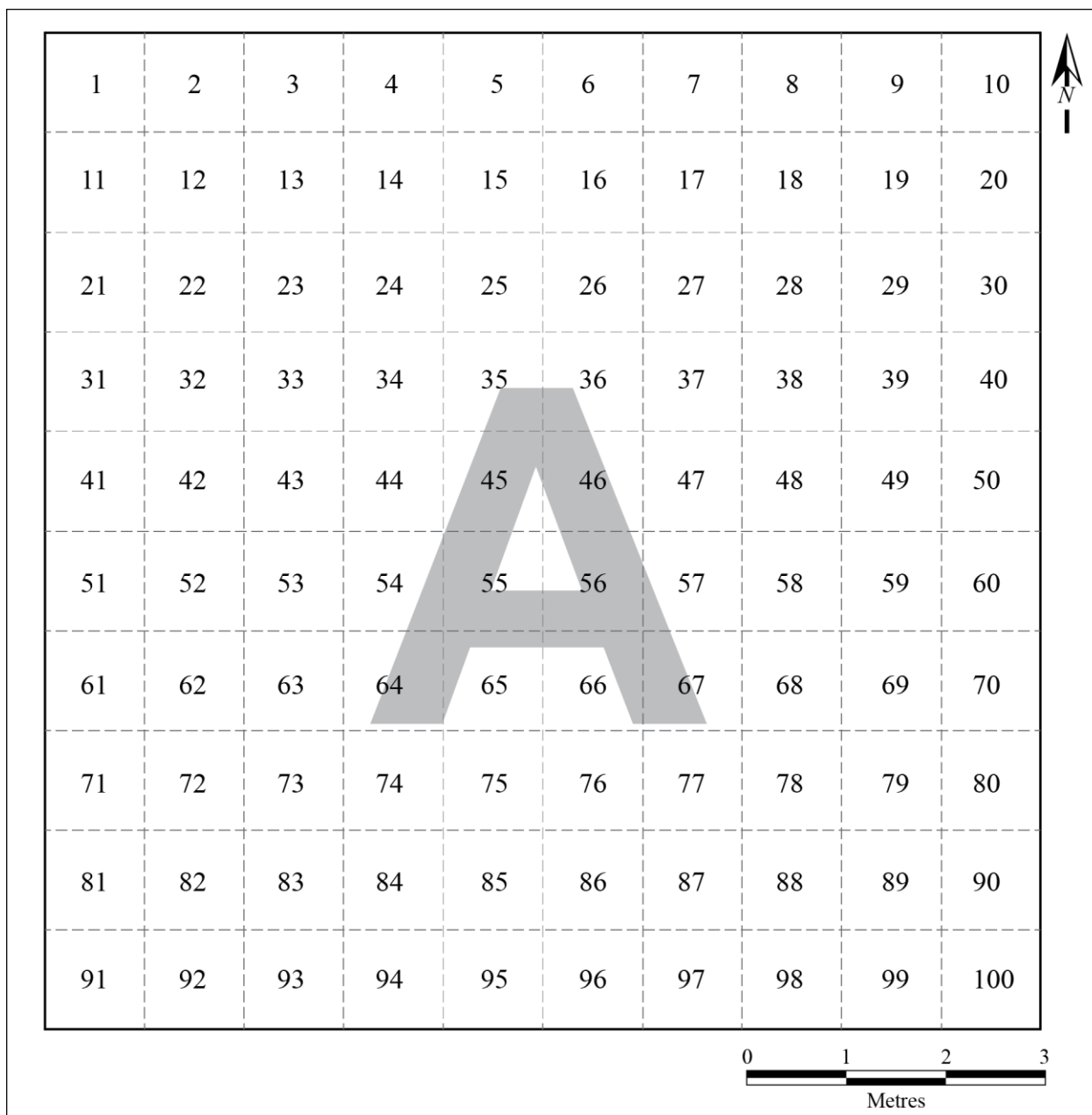


Figure 4.2-2. Excavation area naming convention (area A shown).

Professional judgment was used to determine the size of evaluative tests. Primary magnetometry targets were initially subject to 0.5 m x 0.5 m test units to verify that hearth deposits were present. All test units proved positive for hearth deposits and were subsequently expanded in order to provide a more complete understanding of the hearths and their relationships to adjacent stone circle features.

Units were excavated in 5 cm arbitrary levels. All cultural materials encountered during excavation were mapped in situ (using point provenience) whenever possible (unless recovered

in the screen) and collected. Matrix samples were taken from hearth deposits at 5 cm intervals. All excavated sediment, with the exception of collected matrix samples, was screened through 3 mm mesh in order to recover fine debitage and other cultural materials. During excavation, care was taken to observe changes in soil colour (documented with Munsell soil colour charts), the presence of organics, faunal remains, and fire broken rock (which were mapped and collected when possible).

4.2.4 Stone Feature Documentation

Stone circles subject to magnetometry surveys were mapped and documented either using a modified "tipi-quik" method (Smith 1974) when three crew members were present or using a 1 m x 1 m mapping frame which was subdivided into 20 cm x 20 cm segments for ease of use and aligned along an east-west oriented chain tied into the magnetometry grid. The tipi-quik method, with modifications based on those outlined by Dau (1981), utilized a board marked with compass bearings, metal stakes to secure the board which was oriented to true north, a metric chain, and tipi-quik recording forms also marked with compass bearings (Figure 4.2-3).

Stone features documented at EkNj-68 that were not subject to magnetometry surveys received limited feature documentation and mapping. In these circumstances, documentation included measuring outer ring diameter, identifying the number of courses of rocks (e.g., single or double rings), counting the number of stones visible on the surface, estimation of how deeply rocks were buried, and whenever possible, identifying the location of gaps in the stone wall. The location and size of each stone feature was plotted onto the site map. All features at this site were recorded using a Garmin GPSmap 60cx.

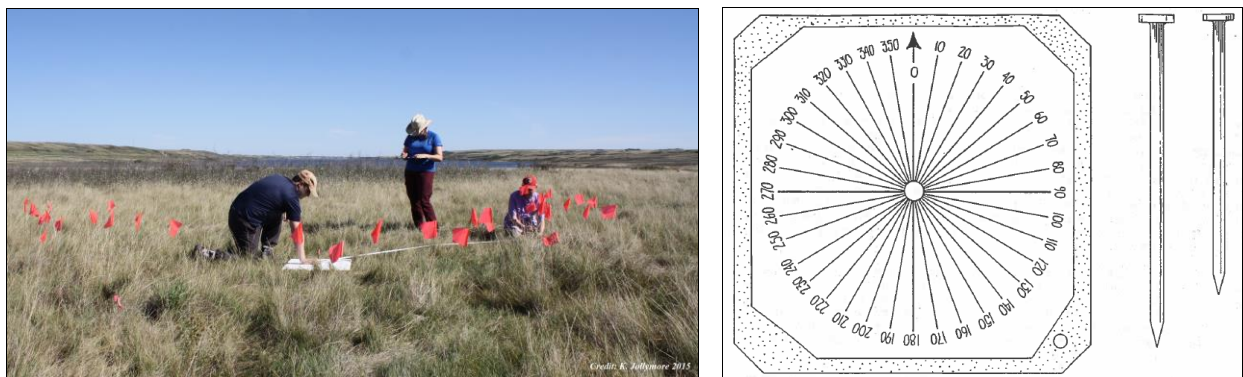


Figure 4.2-3. L: Recording a stone circle at EkNk-3 using the "tipi-quik" method. R: Sketch of tipi-quik apparatus including a board marked with compass bearings and spikes used to anchor/position the board (after Smith 1974:49). A chain is affixed to the central spike and pulled out to the edge of the stone circle.

4.3 Laboratory Methods

4.3.1 Artifacts

Artifacts collected during this study were washed, weighed, measured, and bagged with an artifact catalogue tag according to their assigned Borden and accession numbers. The Royal Saskatchewan Museum (RSM) was contacted prior to cataloging to determine if artifacts had been collected previous to the current research; to the knowledge of the RSM staff, no previous collections had been made.

Diagnostic artifacts (e.g., projectile points) were not recovered during this study. Formed tools recovered during the study were described as to shape, raw material, and manufacturing attributes; appropriate metrics were also recorded.

Lithic debitage was quantified and classified according to raw material type, stage of manufacture, and technological attributes. The debitage analysis was carried out following methods described by Andresfsky (2005) and Kooyman (2000). Material type was recorded for all lithics where possible (e.g., Swan River chert, quartzite, etc.).

Hammerstones and groundstones recovered during this study were subject to inspection under a Kyowa Optical Model SDZ-P dissecting stereomicroscope (7 - 45 x magnification) to identify and evaluate modifications and were described to raw material, size, and other pertinent descriptors.

All pieces of fire broken rock were counted and weighed by unit and level.

4.3.2 Paleobotanicals

Sediment samples were collected from all excavated sites for paleobotanical analysis. Samples were collected with a clean trowel and deposited into large paper bags. Whenever practical, matrix samples were collected in excess of 2 litres of sediment per sample to allow for sufficient material to be floated and analyzed.

Samples were processed according to Pearsall (1989) and were floated in a Model A Flote-Tech machine-assisted flotation system (Figure 4.3-1), which has been demonstrated to be effective for such samples (Hunter and Gassner 1998). All processed samples were measured by volume. Floated botanicals were recovered in 0.3 mm mesh and heavy fraction materials were

recovered in 1 mm mesh. Both light and heavy fractions were labeled and placed on lined drying racks (Figure 4.3-1).



Figure 4.3-1. (L) Model A Flote-Tech machine-assisted flotation system used to process matrix samples. (R) Floated matrix samples on drying racks, awaiting analysis.

Once the light fraction materials were dry, samples were screened and separated into like-sized fractions (>2.0 mm, >1.00 mm, >0.50 mm, and <0.50 mm), weighed, and placed in labelled plastic bags for analysis and storage. Recovered botanicals were processed (sorted and identified) by standard paleobotanical techniques (Pearsall 1989) using a Kyowa Optical Model SDZ-P dissecting stereomicroscope (7 - 45 x magnification). Charred macroremains (*i.e.*, seeds and charcoal) were separated from uncharred components with the assumption that uncharred material represents a modern assemblage (Minnis 1981). The identification of charred materials was facilitated through use of published seed and wood guides (Hather 2000; Hoadley 1990; Kindscher 1987; Martin and Barkley 1961; Montgomery 1977) and the assistance of Dr. Glenn Stuart of the Department of Archaeology and Anthropology of the University of Saskatchewan. Macroremains were quantified by count; seed fragments were counted as half (0.5) each to avoid inflated seed counts. Macroremains were identified to the lowest taxonomic level possible.

Once heavy fraction materials were dry, samples were screened and separated into like-sized fractions (>5.6 mm, >2.8 mm, and <2.8 mm) to recover lithic debitage, faunal fragments, fire broken rock, shell, and any other archaeological materials. Material recovered from the heavy fraction was counted, weighed, and included in the site catalogue.

4.3.3 Faunal and Shell Remains

All collected faunal materials were counted and weighed by unit and level. Faunal material was identified by Dr. Ernest Walker of the Department of Archaeology and Anthropology of the University of Saskatchewan. Classification was to the lowest possible taxonomic level possible and identification to element and side was carried out whenever feasible.

Shell recovered from EkNk-3 was counted and weighed by unit and level. Taxonomic identification was facilitated by recourse to published guides (Clarke 1981; Cvancara 1983) and the assistance of Dr. Alec Aitken of the Department of Geography and Planning of the University of Saskatchewan. Again, classification was to the lowest possible taxonomic level possible.

4.3.4 Radiocarbon Dating and Optically-Stimulated Luminescence Analysis

4.3.4.1 Radiocarbon Dating

Radiocarbon dating of samples collected during the course of this study was conducted by the A.E. Lalonde AMS Laboratory at the University of Ottawa. Recovered grass fragments and twigs which involve only a single season of growth, were analyzed, as such samples have no inherent age off-set (Bowman 1990). Results are presented in Appendix D. For more information on radiocarbon dating and date conventions see Section 1.3.

4.3.4.2 Portable Optically-Stimulated Luminescence

Portable optically-stimulated luminescence (POSL) profiling was used at EkNk-3 to assist in characterizing the sedimentary depositional environments at the site. It is a technique that has been employed since the early 2000s (*cf.*, Bishop et al. 2004) and became commercially feasible in 2010 (Sanderson and Murphy 2010). It results in non-normalized OSL measurements

which are not corrected for factors which influence the luminescence signal (moisture content, grain size, dose rate, mineralogical differences) and does not provide absolute chronometric dates. However, the results provide a quick method of characterizing sediment depositional histories which may be used to infer relative age, identify disturbances, and interpret sedimentary processes over time (Bateman et al. 2015; Stang et al. 2012).

POSL samples were collected from EkNk-3 under low-light conditions (at dusk) and approximately 1 cm of soil was scraped back from each profile prior to sampling. Each sample was collected by hammering 10 cm lengths of 1.9 cm (3/4") copper tubing into vertical unit profiles at regular (2-3 cm) intervals (e.g., Figure 4.3-2). Each tube was collected rapidly and capped at both ends and numbered sequentially. The locations of each sample were plotted onto unit profile diagrams and photographs were taken. Samples were processed by Dr. Krista Gilliland of Western Heritage Services Ltd. under safe light conditions (*i.e.*, using a red light) using a POSL reader (an instrument developed and manufactured by the Scottish Universities Environmental Research Centre).



Figure 4.3-2. POSL sample tubes in place through the hearth identified at EkNk-3 (east wall).

The POSL analysis methods are consistent with those outlined in Sanderson and Murphy (2010) and are summarized here. The POSL unit includes a detector head containing a photomultiplier tube mounted over a sample drawer system, a control box to trigger the stimulation sources, and a computer to provide user interface and a means of logging data from the unit. Measurement sequences from samples include a red stimulation at 880 nm (infra-red stimulated light [IRSL], providing a feldspar-dominated signal) and a blue stimulation at 470 nm (optically stimulated light [OSL], providing a polymineral-derived signal). Samples are placed into 50 mm diameter polystyrene Petri dishes and placed into the sample drawer for processing. Analysis of the luminescence profiles was carried out by Dr. Krista Gilliland of Western Heritage who examined and interpreted graphs derived from numerical data (see Appendix E).

The photon counts reflect the luminescence signals generated by sediments in response to the two stimulation sources (IRSL-red; OSL-blue). Changes in the number of photon counts can reflect a diverse range of sediment properties, including relative age of deposition, grain size, moisture content, colour, environmental dose rate, luminescence sensitivity, and mineralogy. As POSL results do not correct for these variables, fluctuations in photon counts are interpreted using known sediment characteristics obtained from stratigraphic descriptions, geological and geomorphological data for the area, and the context of the optical signals derived from adjacent sediments samples within the profile (Dr. Krista Gilliland, personal communication 2016).

The depletion ratios are calculated by dividing the number of photon counts generated during the first half of each stimulation by the number of counts generated during the second half. These ratios are used as an indicator of how quickly the luminescence signal of a sample fades during stimulations. In general terms, the amount of exposure time needed to reset the fast component of a sediment's luminescence signal is reduced with every exposure event (Duller and Wintle 2012; Pietsch et al. 2008; Roberts et al. 2015). The depletion ratio in POSL measurements can therefore be interpreted to produce estimates of sediment depositional histories (Dr. Krista Gilliland, personal communication 2016).

The IRSL/OSL ratio, which is an estimate of relative amounts of feldspar to quartz, can be used to infer mineral weathering, soil formation, and/or mineralogical changes, such as influxes of sediment from different sources (Sanderson and Murphy 2010).

4.4 Spatial Analyses

All mapping and spatial analyses relating to aspects of this project were carried out using ESRI ArcGIS 10.3 and the suite of tools contained therein. More specifically this research involved the use of Average Nearest Neighbor (Spatial Statistic), Point Distance (Analysis), Buffer (Analysis), Viewshed (Spatial Analyst), and Raster Calculator (see Chapter 6). Digital elevation model (DEM) data, used for some of the analyses, was based on the Saskatchewan Geospatial Imagery Collaborative (SGIC) DEM raster dataset with raster cell sizes measuring 15 m x 15 m. Raster values were extracted from this dataset for archaeological site locations using the Extract Values to Points (Spatial Analyst) and Features to 3D By Attribute (3D Analyst) tools. Locational information for the archaeological sites was obtained from ARMS and consisted of point data for site datums. Site boundaries and feature locations within the sites were obtained from the SARR forms provided by ARMS.

4.5 Site Documentation and Curation

A Saskatchewan Archaeological Resource Record (SARR) was completed for the newly documented site (EkNj-68). Site boundaries were defined using landforms and observed limits, defined as an area containing the extent of archaeological materials and/or features. SARR Update Forms were completed for those sites that were revisited during the course of this study through documentation of the location of surface features, magnetometry survey areas, and all subsurface testing that was carried out during this study. Soil and sediment descriptions were recorded in field notes and are outlined in Chapter 5 and Appendix C.

All artifacts and associated archaeological materials collected during the course of this study have been curated at the Royal Saskatchewan Museum as per requirements outlined in HRIA Permit 2015-063.

Chapter 5

Excavation Results

This chapter presents the results of archaeological investigations carried out during the 2015 field season at EkNj-4, EkNj-68, and EkNk-3 (Figure 5-1); a complete discussion of the results is presented in Chapter 7. Additional information (artifact catalogues, debitage analysis, maps, magnetometry results, etc.) can be found in Appendices A through E.

5.1 EkNj-4

Archaeological site EkNj-4 is a precontact multiple feature site located on a terrace overlooking the northern shore of Little Manitou Lake (Figures 5-1 and 5.1-1). The site consists of 41 stone circles, one arc/partial stone circle, and 10 stone cairns (Rescan 2011). Site boundaries measure 560 m (N-S) x 320 m (E-W). The area selected for detailed investigation was focused on an area roughly in the centre of this large site at a cluster of stone circles approximately 470 m north of Little Manitou Lake at 541 m asl (Figure 5.1-2).



Figure 5.1-1. View south across southern half of EkNj-4 and toward the Little Manitou Lake valley.

5.1.1 Magnetometry, Feature Mapping, and Magnetic Susceptibility

Magnetometry surveys were carried out over five stone circle features (Features 6, 7, 8, 50, 51). All rocks within each 10 x 10 m magnetometry grid were mapped and their locations

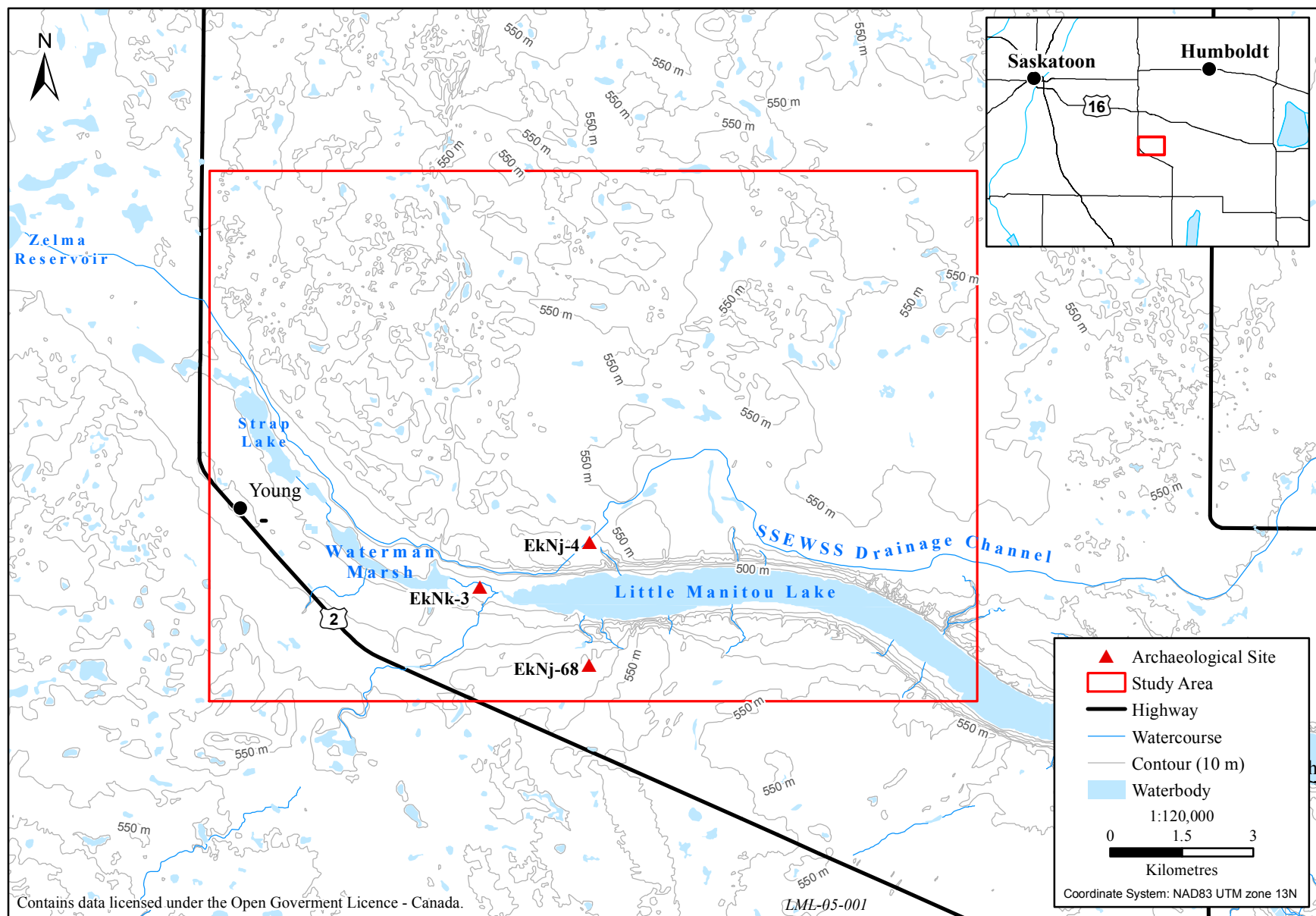


Figure 5-1. Study area and locations of EkNj-4, EkNj-68, and EkNk-3.

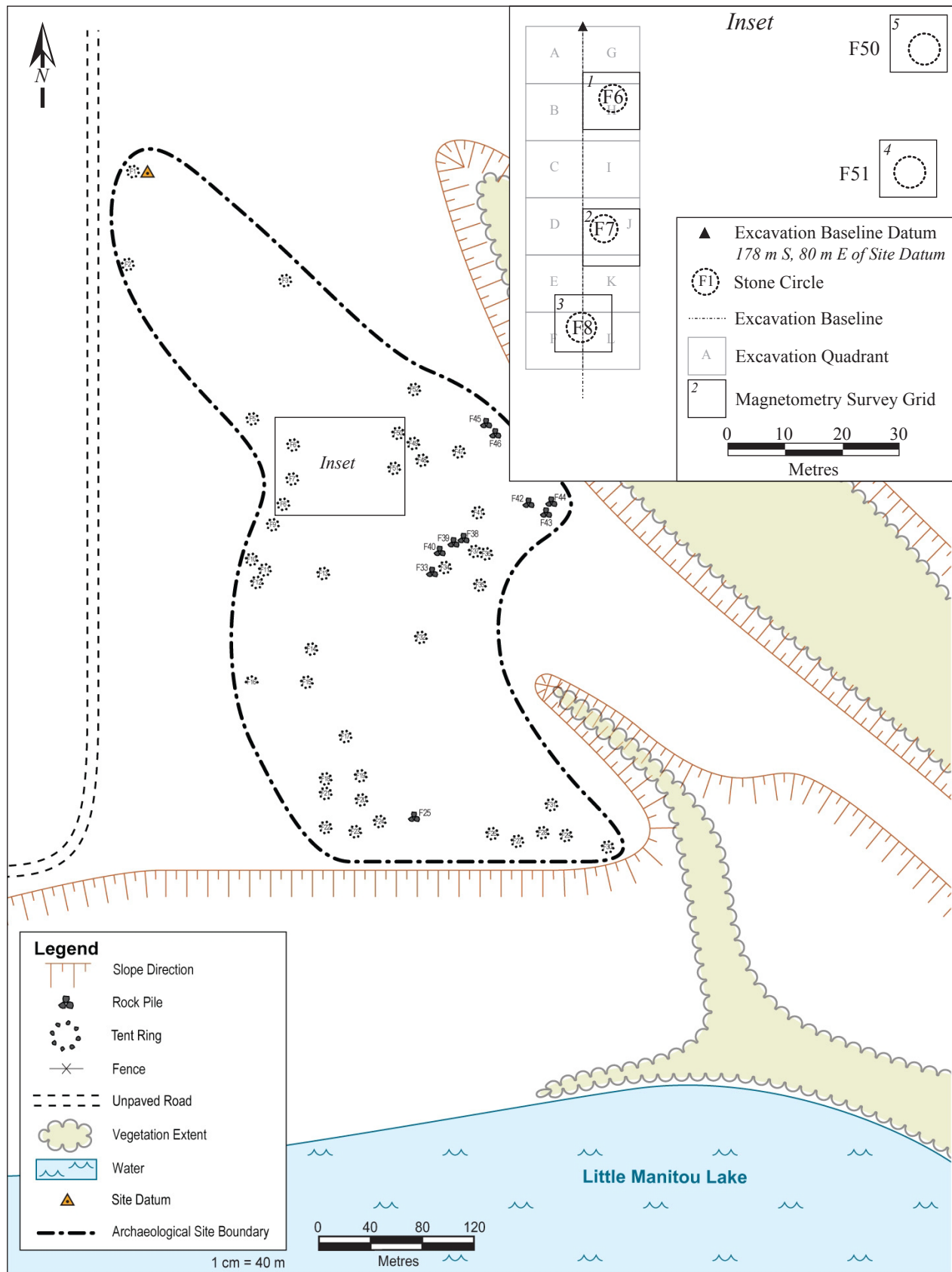


Figure 5.1-2. Focused area of investigation at EkNj-4 (primary map after Rescan 2011).

correlated with magnetic anomalies. These results were used to identify a target area adjacent to Feature 7 for subsurface investigation (Figure 5.1-3; see Appendix A1 for detailed magnetometry maps for all other stone circle features evaluated).

Matrix samples were collected from a hearth feature identified during subsurface investigations adjacent to ring Feature 7 and a column sample was taken from an area south of ring Feature 7 where magnetic anomalies were absent (as documented by magnetometry surveys; Figure 5.1-3). Soil from the matrix and column samples was subject to post-excavation magnetic susceptibility analysis, the results of which are presented in Table 5.1-1.

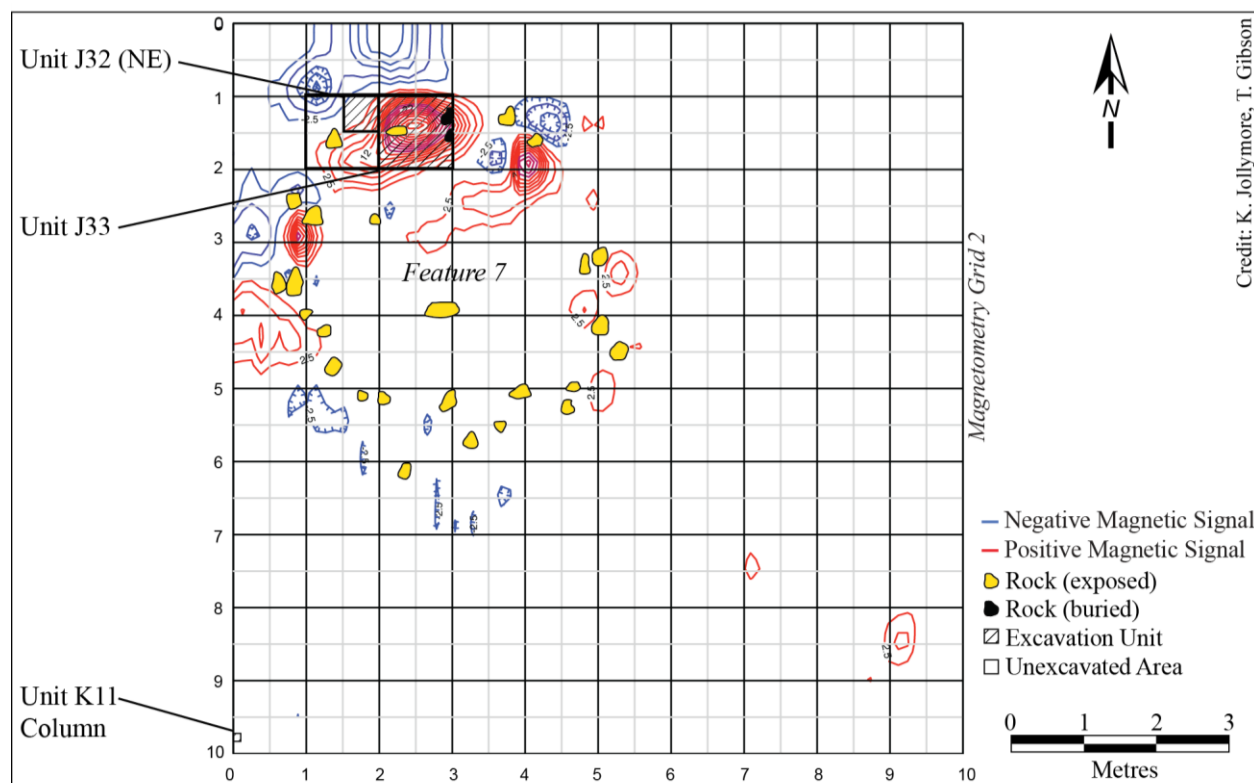


Figure 5.1-3. Mapped rocks of Feature 7, magnetometry results for Grid 2, and area of subsurface excavation at EkNj-4. Magnetic data shown in 1nT intervals, starting -2.5/2.5 nT.

Table 5.1-1. Results of magnetic susceptibility evaluations carried out on matrix samples from EkNj-4.

Sample	Unit	Level	Depth Below Surface (cm)	Unit Provenience (cm)	Mass (g)	Context of Collection	KT-10 Harmonized to 20 g (SI units)
2	J33	2	8-9	0-30 E, 50-100 N	30	Middle of hearth	0.125
3	J33	3	10-12	0-25 E, 50-100 N	30	Middle of hearth	0.154
4	J33	3	13-14.5	0-25 E, 50-100 N	30	Bottom of hearth	0.133
5a	K11	1	0-5	0-10 E, 20-30 N	20	Column	0.029
5b	K11	2	5-10	0-10 E, 20-30 N	20	Column	0.059
5c	K11	3	10-15	0-10 E, 20-30 N	20	Column	0.072

5.1.2 Excavation Results

As noted earlier in this thesis, by design only a small area at this site was targeted for excavation with the express purpose of locating hearth deposits, resulting in a total area of 1.25 m² excavated at EkNj-4. Due to the small excavation area, it should be noted that recovered cultural material may not be representative of the entire stone circle which was under investigation. However, while not necessarily representative of the whole ring, because excavations focused on hearth deposits, which have been suggested to have been used as waste receptacles, recovered cultural material may still represent a broader picture of the artifact record at this ring than might be expected for similar sized excavation areas that are not located on hearth features.

Units excavated at the site were: J32 (NE quadrant only) and J33, both associated with ring Feature 7. Excavations were carried out in 5 cm arbitrary levels. These excavations resulted in the recovery of 17 artifacts (Table 5.1-2 and discussed further below) and the identification of a hearth feature (Figure 5.1-4 and described below). The cultural material recovered from EkNj-4 include one retouched flake, nine pieces of lithic debitage (2.33 g), one pebble hammerstone, one polishing stone, one piece of ochre pigment, three fragments of bone (likely *Bison* sp.), and one birdshot pellet. See Appendices B1 and C1 for additional details.

Table 5.1-2. Summary of artifacts recovered from EkNj-4.

Artifact Type	Quantity (n=x)	Percentage of Collection (%)
Lithic debitage	9	52.94
Retouched flakes	1	5.88
Hammerstones	1	5.88
Polishing stones	1	5.88
Pigment	1	5.88
Faunal remains	3	17.65
Ammunition	1	5.88
Total	17	100

Soil at the site is a Vertic Dark Brown Chernozem, a nutrient rich soil that develops in a sub-humid climate under grassland vegetation. This soil subgroup differs from other subgroups within the Dark Brown Chernozemic Great Group by having properties that are indicative of integrating with the Vertisolic Order (Soil Classification Working Group 1998). While this soil type does not meet the qualifications of the Vertisolic Order, it can exhibit slickenside horizons due to the soil's tendency to shrink and swell and the presence of at least 60% clay in the soil matrix (Brierley et al. 2011). This vertic action results in the opening of cracks which can allow

materials from the surface or soil particles along the walls of the cracks to fall down into deeper locations. The closing of cracks and the swelling process can also push material up through the soil and induce lateral shifting (Holliday 2004). As such, vertic action can have a significant effect of archaeological deposits by moving artifacts either up to the surface or deeper into the soil.

The site falls within an area assigned as soil unit Wr12:1 of the Weyburn soil association, 3rd a designation assigned during soils mapping carried out by the R.M. of Viscount (Saskatchewan Soil Survey 1990). However, more recent soil mapping suggests that the soil association for the site area is more consistent with the Weyburn-Elstow soil complex (Rescan 2012a). This soil complex consists of a dark brown soil formed in a mixture of loamy glacial till (Weyburn) and shallow, silty lacustrine materials (Elstow) resulting in loam to clay loam (WrEw) surface textures which occur on hummocky landscapes with gentle to moderate slopes (Rescan 2012a; Saskatchewan Soil Survey 1990).

The soil profile for the units excavated at the site consists of a dark brown (10YR 2/2) stratum of organics and littermat (stratum I), a black (10YR 2/1) stratum of loamy clay with gravel which exhibits vertic characteristics (stratum IIa), a black (10YR 2/1) stratum containing charcoal denoting the location of a hearth (stratum IIb), a very dark greyish brown (10YR 3/2) stratum of silty clay with gravel (stratum IIc), and a stratum of dark greyish brown (10YR 4/2) clay with gravel and a few large cobbles (stratum III) (Figure 5.1-4 and Appendix C1).

Stratum I is shallow ranging between 0 and 5 cm depth below surface (DBS). Stratum II (IIa, IIb, and IIc) ranges between 5 and 25 cm DBS. Cultural material was confined to this stratum with the exception of a piece of debitage, a retouched flake, and a piece of charcoal which were found at the interface between strata I and IIa (EkNj-4:1, 5, and C1). IIa denotes a slickenside stratum where vertic action has occurred, in some cases extending beyond the ~30 cm maximum depth which was excavated. In some areas, the distinction between the IIa vertic stratum and the IIb hearth stratum was difficult to discern as both are very dark and the soil throughout the site was damp during excavation, making soil colour differentiation difficult to observe. However, the hearth has a distinctive bowl shape which allowed for the interface between IIa and IIb to be inferred.

Interestingly, some of the rocks and pebbles present in the soil are of types that are often used for the manufacture of stone tools, such as tan/beige coloured chert and Swan River chert,

or pebbles used as pigments, such as ochre. To differentiate between natural and cultural lithic material, lithics of these material types collected during excavations were subject to inspection under a Kyowa Optical Model SDZ-P dissecting stereomicroscope (7 - 45 x magnification) to verify the presence or absence of typical cultural modifications.

The hearth was found in Units J32 and J33 and was identified by the observed presence of charcoal, blackened soil and lithic debitage (stratum IIb) (Figure 5.1-4 and Appendix C1). The overall dimensions of the hearth are 30 cm E-W by 42 cm N-S and at its deepest point it is 14 cm thick (4 cm to 18 cm DBS). Four matrix samples were collected from different depths within the hearth (see Section 5.1.2.4 and Table 5.1-5). Charcoal recovered from matrix samples 1 and 2 were submitted for AMS analysis returning dates for material recovered from 6 to 9 cm DBS, roughly the upper-middle of the hearth. No fire cracked rock was recovered, however, one large cobble identified as a polishing stone (EkNj-4:8) was recovered from the bottom of the hearth (Section 5.1.2.1). Three pieces of lithic debitage and one retouched flake were recovered from the hearth and three faunal fragments, which do not show signs of burning, were recovered immediately adjacent to the hearth (Section 5.1.2.2).

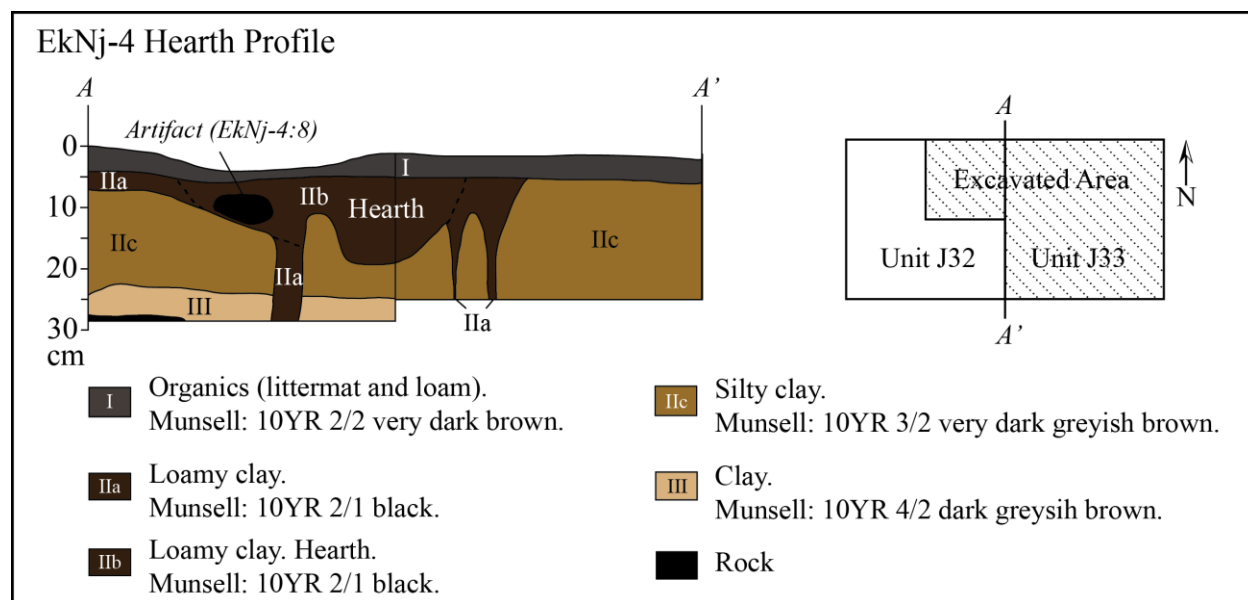


Figure 5.1-4. Profile of hearth excavated at EkNj-4.

5.1.2.1 Lithic Material

Three stone tools were recovered from the 1.25 m² excavated at EkNj-4 (Table 5.1-2). These artifacts consist of one retouched flake, one hammerstone, and one polishing stone. No diagnostic points or formed tools were recovered. The retouched flake was made of Swan River

chert, the hammerstone was made of quartzite, and the polishing stone was made of fine-grained quartzite (Figure 5.1-5). In addition one piece of ochre pigment was recovered, though it is unclear whether it is of cultural significance. See Appendix C1 for artifact photographs and catalogue.

Nine pieces of lithic debitage with a total mass of 2.33 g were recovered from the 1.25 m² excavated at EkNj-4. Raw lithic materials of recovered debitage consist of chert (44%; n=4), quartzite (33%; n=3), and Swan River Chert (22%; n=2); no exotic lithic materials (that is material which has been imported or traded into the region) were recovered (Figure 5.1-5).

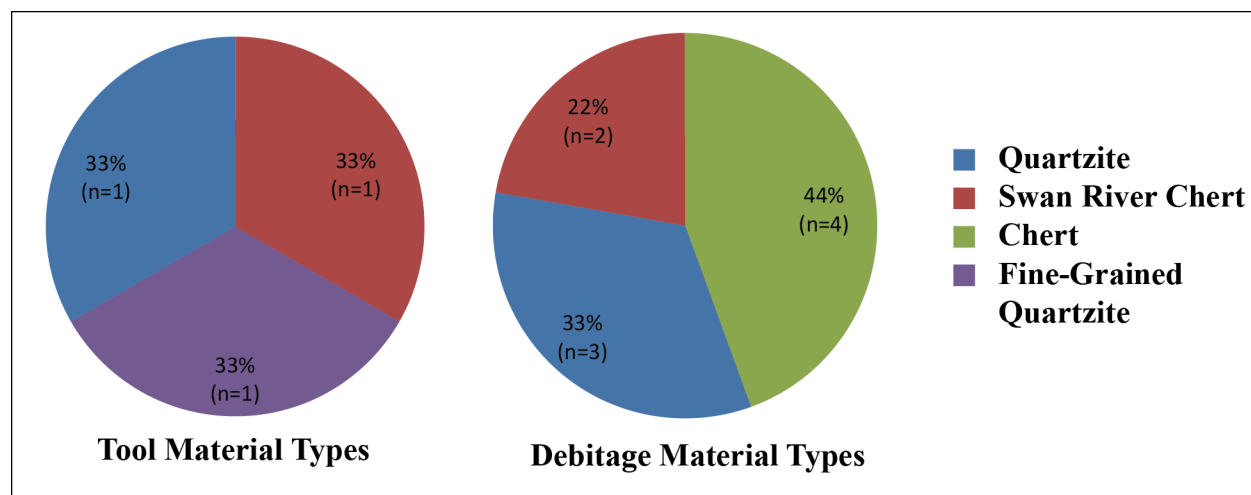


Figure 5.1-5. Summary of lithic material types recovered from EkNj-4.

The debitage analysis carried out on this collection is summarized in Table 5.1-3 (also see Appendix B1). The debitage consists primarily of small flakes and fragments less than 1 cm in maximum dimension with 56% falling into the 0.25 to 0.5 cm size range, 22% falling into the 0.5 to 1.0 cm size range, and 22% falling into the >1.0 cm size range (Table 5.1-3). Of the debitage, 44% of recovered lithic debitage were complete flakes, 11% were broken flakes, and 44% consisted of block shatter/debris. The vast majority of debitage (67%; n=6) consisted of pressure/finishing flakes while the remainder consisted of hard hammer/core reduction flakes (33%; n=3).

The lithic debitage recovered from Feature 7 suggests that lithic reduction was likely primarily focused on late-stage shaping/resharpening rather than earlier stages of lithic reduction. Although only a small area was excavated, the absence of formed tools, the lack of cortical flakes, and the frequency of small late-stage debitage may suggest maintenance and curation of

the toolkit being used. The absence of exotic raw lithic material may also suggests a reliance of locally available lithic resources.

Table 5.1-3. Summary of debitage recovered from EkNj-4.

Flake Size (cm)				
<0.1 0%	0.1-0.25 0%	0.25-0.5 56%	0.5-1.0 22%	>1.0 22%
Flake Completeness				
Complete Flakes 44%	Broken Flakes 11%	Flake Fragments 0%	Debris 44%	Split Flakes 0%
Flake Type				
Biface Thinning Flakes 0%	Hard Hammer/Core Reduction Flakes 33%	Pressure/Finishing Flakes 67%	Bipolar Flakes 0%	Cortical Flakes 0%

5.1.2.2 Faunal Remains

Three pieces of unburnt bone were recovered from level 2 of Unit J33 (5-10 cm DBD). The largest piece, a fragment from a large mammal - a gracile bone fragment which is likely from a bison tibia, was found adjacent to the hearth feature wedged under the southwestern edge of a ring rock near the center of unit J33 (Figure 5.1-6; see Appendix C1 for unit plan view). Two other unidentifiable bone fragments were recovered, one found several centimeters to the north and west of the largest piece and one recovered from the screen.

5.1.2.3 Historic Material

One piece of lead shot was recovered from level 3 (10-15 cm DBS, found in the screen) from unit J33. It is a No. 6 (0.11"/2.9 mm) birdshot pellet which has been badly degraded and is in poor condition (Figures 5.1-7 and 5.1-8; Barnes 2000). Firearms and shot used for hunting birds and other game were traded to aboriginal groups in the parkland and grassland regions of Canada (Ray 1998). Although the shot was found with lithic debitage, it is possible that it is not contemporaneous with the other cultural materials recovered. It may be of historic/modern origin as a result of gopher hunting, or more likely fowl or game bird hunting, and came to be interred in level 3 through bioturbation, namely rodent burrowing (a rodent burrow was observed in the southern half of this unit extending into level 4) and/or vertic soil mixing. Gopher hunting is typically carried out using No. 4 buckshot (6 mm) (Lawrence 2002; Shot Gun World 2003b),

while No. 6 birdshot is typically used for hunting small birds such as ruffed grouse (Shot Gun World 2003a) (see Section 5.3.2.3 for additional details).



Figure 5.1-6. Faunal material recovered during excavations at EkNj-4 and EkNk-3. L to R: Three fragments of unidentifiable large ungulate (likely *Bison* sp.) recovered from EkNj-4 (EkNj-4:12-14) and a *Bison* sp. internal carpal (right side) from EkNk-3 (EkNk-3:44).

Lead shot sizes:	12	9	8 1/2	8	7 1/2	6	5	4	2	BB
Pellet diameter	●	●	●	●	●	●	●	●	●	●
(inches)	.05	.080	0.85	0.90	.095	.110	.120	.130	.150	.180
(mm)	1.27	2.30	2.16	2.29	2.41	2.79	3.05	3.30	3.81	4.57

Figure 5.1-7. Lead birdshot pellet sizes (after Discover the Outdoors 2009).



Figure 5.1-8. Historic shot pellets recovered during excavations at EkNj-4 and EkNk-3. L to R: No. 6 lead birdshot (EkNj-4:15), No. 4 lead birdshot (EkNk-3:21), No. 2 lead birdshot (EkNk-3:22).

5.1.2.4 Paleobotanical Remains

During excavation, four soil matrix samples were collected which were processed through flotation in order to recover charred organics (Table 5.1-4). All samples yielded charcoal and three samples yielded seeds; a brief inventory of recovered paleobotanicals is outlined in Table 5.1-5. Macroremains recovered from these samples included *Chenopodium* sp. (goosefoot), *cf.*, *Scirpus* (bullrush), Poaceae (grass family), and unidentifiable seeds. Three pieces of charcoal were large enough to be snapped in half to allow for cross-section view; one piece was identified as *Salix* sp. (willow) while the second piece was not large enough to differentiate between *Populus* sp. (poplar/aspen) or *Salix* sp. (willow) and thus was identified as *Salix/Populus*. The third piece was large enough to observe a semi-porous structure but could not be identified to species. The small size of the remaining charcoal fragments preclude their identification. Three additional pieces of charcoal were recovered from the screen during excavations of unit J33, one identified as *Alnus* sp. (alder) and two others identified as twigs which could not be identified to species.

Table 5.1-4. Matrix samples subject to flotation and paleobotanical analysis from EkNj-4.

Sample	Unit	Level	Depth Below Surface (cm)	Unit Provenience (cm)	Volume (ml)	Context of Collection
1	J33	2	6-7	0-30 E, 70-100 N	1625	Top of hearth
2	J33	2	8-9	0-30 E, 50-100 N	2000	Middle of hearth
3	J33	3	10-12	0-25 E, 50-100 N	2000	Middle of hearth
4	J33	3	13-14.5	0-25 E, 50-100 N	2000	Bottom of hearth

5.1.3 Radiocarbon Dates

Two samples recovered from matrix samples taken at EkNj-4 were sent to the A.E. Lalonde AMS Laboratory at the University of Ottawa for analysis. These included only the charcoal fragments recovered from matrix samples 1 and 2 (Table 5.1-4): EkNj-4:C1 and EkNj-4:C2, from the top and middle of the hearth respectively (Table 5.1-6). Dates returned for both samples were very similar and likely represented the minimum date of use for this feature. Charcoal fragments included grasses, stems, and twigs produced during a single season of growth. Some small charred bark fragments were observed in the samples and were removed prior to analysis (charred bark fragments: n=144 from EkNj-4:C1; n=27 from EkNj-4:C2). The volume of charred material recovered from matrix samples 3 and 4 was insufficient for AMS analysis. See Appendix D for further details.

Table 5.1-5. Summary of paleobotanical plant taxa* recovered from EkNj-4.

Taxon	Common Name	Plant part(s)	Tally (by Matrix Sample)	Present in Matrix Sample
<i>Chenopodium</i> sp.	Goosefoot sp.	Seed	10 6	1 2
Poaceae	Grass	Seed	4 1	1 2
cf., <i>Scirpus</i>	Compares favourably with Bullrush	Seed	1	1
Unidentifiable seed /seed fragment		Seed	5 5 2	1 2 4
Charcoal - <i>Alnus</i> sp.	Alder	Twig	1	Screen - Unit J33, Level 2
Charcoal - <i>Salix</i> / <i>Populus</i>	Identified as either Willow, Poplar, or Aspen	Twig	1	2
Charcoal - <i>Salix</i> sp.	Willow	Twig	1	2
Charcoal -semi-porous	Identified to cell structure but not to species	Twig	1	1
Charcoal - Unidentifiable		Twig	2	Screen - Unit J33, Level 2
Charcoal fragments -Unidentifiable		Unknown (grass, wood, stems, twigs, etc.)	536 236 69 26	1 2 3 4

*Only recovered charred macroremains are presented in this table.

Table 5.1-6. Charcoal samples from EkNj-4 subject to AMS radiocarbon analysis.

Sample	Unit	Level	Depth Below Surface (cm)	Unit Provenience (cm)	Mass (mg)	¹⁴ C yr BP	Calibrated year AD
EkNj-4:C1	J33	2	6-7	0-30 E, 70-100 N	80	158 ± 20	1667-1954
EkNj-4:C2	J33	2	8-9	0-30 E, 50-100 N	80	160 ± 19	1667-1954

5.1.4 EkNj-4 Summary

Results of the excavation carried out at EkNj-4 date this site to the Protocontact period based on the radiocarbon analysis of charred organics recovered from the hearth. Of the area excavated adjacent to ring Feature 7, recovered cultural materials include one retouched flake, nine pieces of lithic debitage, one pebble hammerstone, one polishing stone, a piece of ochre pigment, three fragments of bone (likely *Bison* sp.), and one lead birdshot pellet. In addition, recovered paleobotanicals, including seeds of *Chenopodium* sp. (goosefoot), cf., *Scirpus* (bullrush), and Poaceae (grass family), and charcoal from *Salix* sp. (willow), *Populus*/*Salix* (poplar, aspen, willow) and *Alnus* sp. (alder), provide a glimpse of the plant life at the site. See Chapter 7 for discussion and interpretation of the excavation results.

5.2 EkNj-68

Archaeological site EkNj-68 is a precontact recurrent feature site (a site with more than two features of the same kind; Archaeological Resource Management Section 2013) located approximately 950 m south of Little Manitou Lake in an area of rolling topography at 541 m asl (Figures 5-1 and 5.2-1). The site was previously known to the landowner but was unrecorded; it was documented during this study and a SARR form was filed with the Heritage Conservation Branch. It consists of 15 stone circles and measures 155 m (N-S) x 160 m (E-W) (Figure 5.2-2). The area selected for detailed investigation focused on the southwestern side of the site at a cluster of stone circles.



Figure 5.2-1. View north toward EkNj-68 and the Little Manitou Lake valley.

5.2.1 Magnetometry, Feature Mapping, and Magnetic Susceptibility

Magnetometry surveys were carried out over six stone circle features (Features 9, 10, 11, 12, 13, 14). All rocks within each 10 x 10 m magnetometry grid were mapped and their locations correlated with magnetic anomalies. These results were used to identify a target area adjacent to Feature 11 for subsurface investigation (Figure 5.2-3; see Appendix A2 for detailed magnetometry maps for all other stone circle features evaluated).

Matrix samples were collected from a hearth feature identified during subsurface investigations adjacent to ring Feature 11 and a column sample was taken from an area north of ring Feature 11 where magnetic anomalies were absent (as documented by magnetometry surveys; Figure 5.2-3). Soil from the matrix and column samples was subject to post-excavation magnetic susceptibility analysis, the results of which are presented in Table 5.2-1.



Figure 5.2-2. Site map of EkNj-68 with area of detailed investigation.

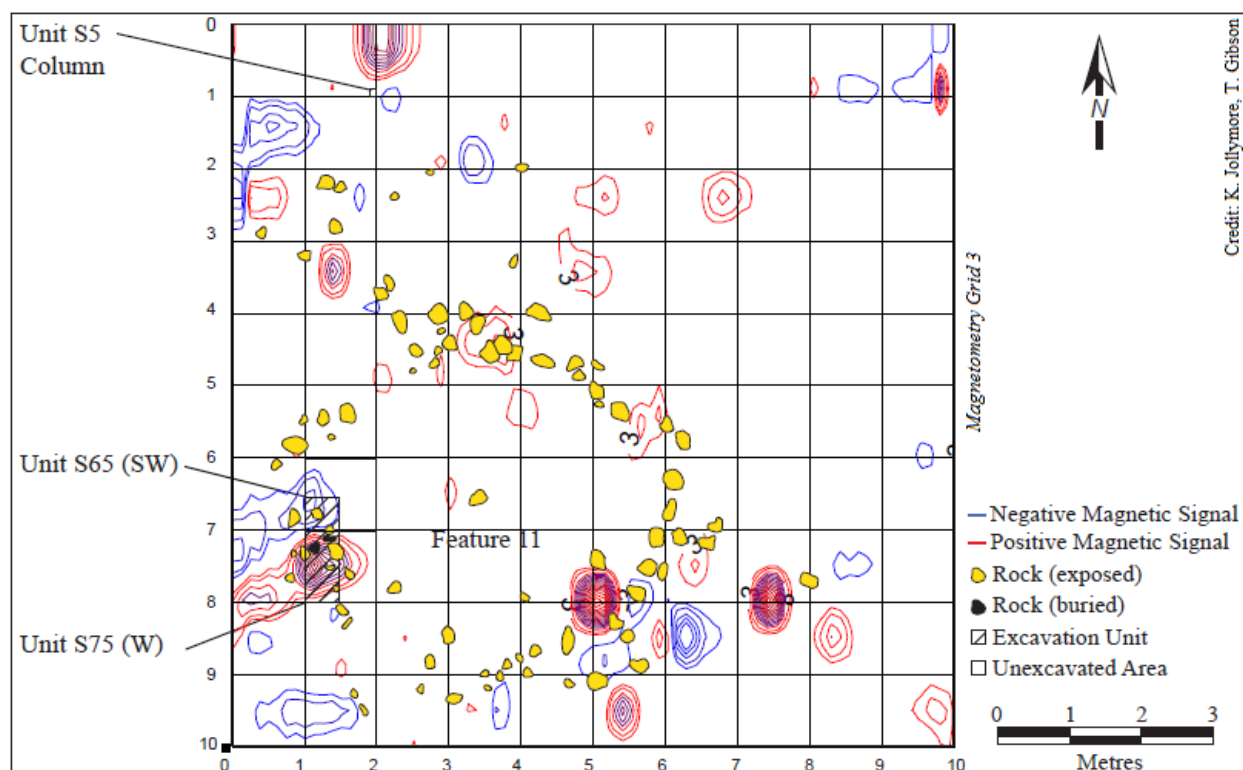


Figure 5.2-3. Mapped rocks of Feature 11, magnetometry results for Grid 3, and area of subsurface excavation at EkNj-68. Magnetic data shown in 1nT intervals, starting -3/3 nT.

Table 5.2-1. Results of magnetic susceptibility evaluations carried out on matrix samples from EkNj-68.

Sample	Unit	Level	Depth Below Surface (cm)	Unit Provenience (cm)	Mass (g)	Context of Collection	KT-10 Harmonized to 20 g (SI units)
1	S65	2	8-12	0-25 E, 0-14 N	30	Hearth	0.186
2	S75	2	10-12.5	20-40 E, 55-80 N	30	Hearth	0.196
3	S75	2	12-15	0-30 E, 70-100 N	30	Hearth	0.167
4a	S5	1	0-5	90-100 E, 0-10 N	20	Column	0.129
4b	S5	2	5-10	90-100 E, 0-10 N	20	Column	0.176

5.2.2 Excavation Results

As noted earlier in this thesis, by design only a small area at this site was targeted for excavation with the express purpose of locating hearth deposits, resulting in a total area of 0.75 m² excavated at EkNj-68. Due to the small excavation area, it should be noted that recovered cultural material may not be representative of the entire stone circle which was under investigation. However, while not necessarily representative of the whole ring, because excavations focused on hearth deposits, which have been suggested to have been used as waste receptacles, recovered cultural material may still represent a broader picture of the artifact record

at this ring than might be expected for similar sized excavation areas that are not located on hearth features.

Units excavated at the site were: S65 (W half only) and S75 (SW quadrant only), both associated with ring Feature 11. Excavations were carried out in 5 cm arbitrary levels. These excavations resulted in the identification of a hearth feature (Figure 5.2-4). In total, one utilized flake, one retouched flake, 15 pieces of lithic debitage (1.95 g), one hammerstone, one polishing stone, and one piece of ochre pigment were recovered from EkNj-68 (Table 5.2-2 and discussed further below). See Appendices B2 and C2 for additional details.

Table 5.2-2. Summary of artifacts recovered from EkNj-68.

Artifact Type	Quantity (n=x)	Percentage of Collection (%)
Lithic debitage	15	75.00
Retouched flakes	1	5.00
Utilized flakes	1	5.00
Hammerstones	1	5.00
Polishing stones	1	5.00
Pigment	1	5.00
Total	20	100.00

Soil at the site is a Calcareous Dark Brown Chernozem, a soil that develops in a semi-arid climate under grassland vegetation of grasses and forbs, has an A horizon which is dark, and has a B horizon which contains alkaline earth carbonates that have not been removed completely (Rescan 2012a; Soil Classification Working Group 1998).

The site falls within an area assigned as soil unit WrEw4:1 of the Weyburn-Elstow soil complex, a designation assigned during soil mapping carried out by the R.M. of Morris (Saskatchewan Soil Survey 1991). This complex consists of a Dark Brown soil formed in a mixture of loamy glacial till (Weyburn) and shallow, silty lacustrine materials (Elstow) resulting in loam to clay loam (WrEw) surface textures which occur on hummocky landscapes with gentle to moderate slopes (Rescan 2012a; Saskatchewan Soil Survey 1991).

The soil profile for areas excavated at the site consists of a greyish brown (10YR 5/2) stratum of littermat and loamy clay (stratum I), a black (10YR 2/1) stratum of loamy clay containing charcoal denoting the location of a hearth (stratum IIa), a very dark brown (10YR 2/2) stratum of loamy clay with gravel (stratum IIb), and a dark yellowish brown (10YR 4/4) stratum of clay with gravel (stratum III) (Figure 5.2-4 and Appendix C2).

Stratum I is shallow ranging between 0 and 5 cm depth below surface (DBS). Stratum II (IIa and IIb) occurs at variable depths between 1 and 16 cm DBS. Cultural material was distributed throughout strata I and II with the exception of a retouch flake (EkNj-68:20) which was recovered from the interface between strata IIb and III. In addition, two pieces of debitage were recovered from level 4 (15-20 cm DBS/stratum III), however, it is likely that these originated from upper levels from the south wall of unit S65 (EkNj-68:9, 10) and were displaced during wall cleaning.

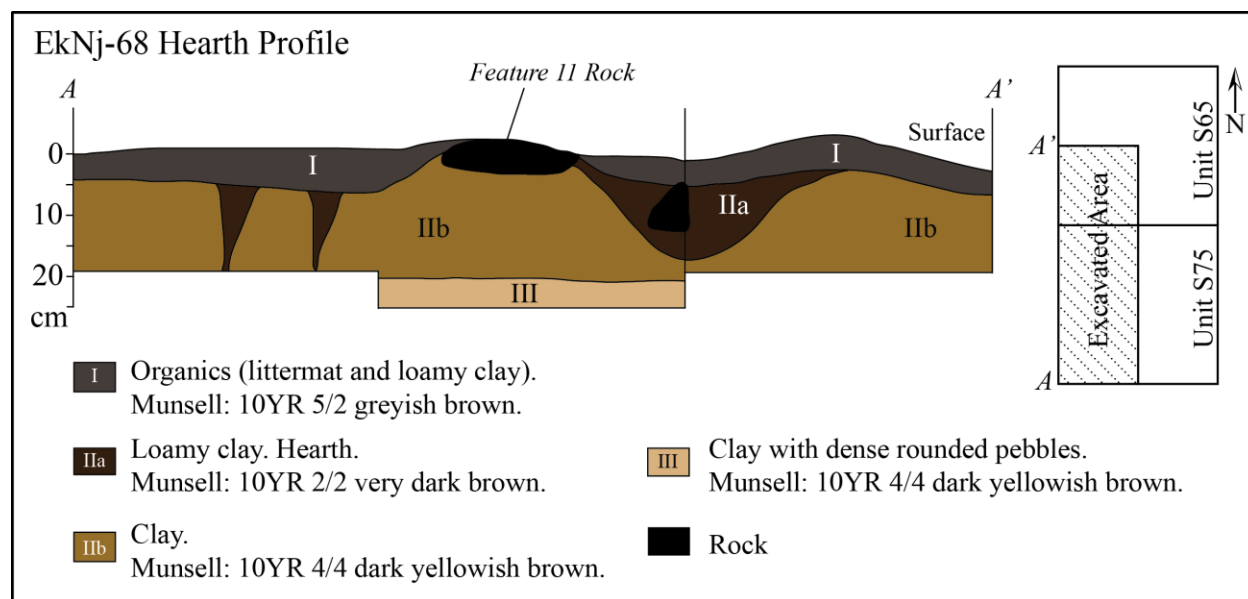


Figure 5.2-4. Profile of hearth excavated at EkNj-68.

As observed at EkNj-4, this site also contained some rocks and pebbles in the soil that are of types often used for the manufacture of stone tools, such as tan/beige coloured chert and Swan River chert, or pebbles used as pigments, such as ochre. In addition, a small piece of red jasper was recovered but was determined to be non-cultural (likely transported to the area by glacial action and deposited in tills). To differentiate between natural and cultural lithic material, lithics collected during excavation were subject to inspection under a Kyowa Optical Model SDZ-P dissecting stereomicroscope (7 - 45 x magnification) to verify the presence or absence of typical cultural modifications.

The distinction between strata IIa (hearth) and IIb was difficult to see as both are very dark and the hearth was not well-defined. The hearth feature was identified by the observed presence of very small flecks of charcoal and spots of blackened soil (Figure 5.2-4). The hearth was located primarily in Unit S75. It also extends north into the southern end of Unit S65 and

likely extends further west into unexcavated Unit S74 and further east into unexcavated portions of Unit S75. As the entire hearth (area evidencing burning) was not excavated and the hearth itself is poorly defined, the overall feature dimensions were difficult to determine. However, the hearth does cover an area of at least 78 cm N-S by 50 cm E-W and at its deepest point measures 13 cm thick (2 cm to 15 cm DBS). One matrix sample was collected from the hearth between 12 and 15 cm DBS and charcoal recovered from the sample was subject to radiocarbon dating (see Tables 5.2-4 and 5.2-6). Fire broken rock was recovered with blackened soil between 15 and 20 cm DBS, immediately below the hearth deposits.

5.2.2.1 Lithic Material

Four stone tools were recovered from the 0.75 m² excavated at EkNj-68 (Table 5.2-2). The artifacts consist of one utilized flake, one retouched flake, one hammerstone and one polishing stone. No diagnostic points or formed tools were recovered. Both the retouched and the utilized flakes were made of Swan River Chert, the hammerstone of quartzite, and the polishing stone of granite (Figure 5.2-5). In addition, one piece of ochre pigment was recovered although it is unclear whether it is of cultural significance. See Appendix C2 for artifact photographs and catalogue.

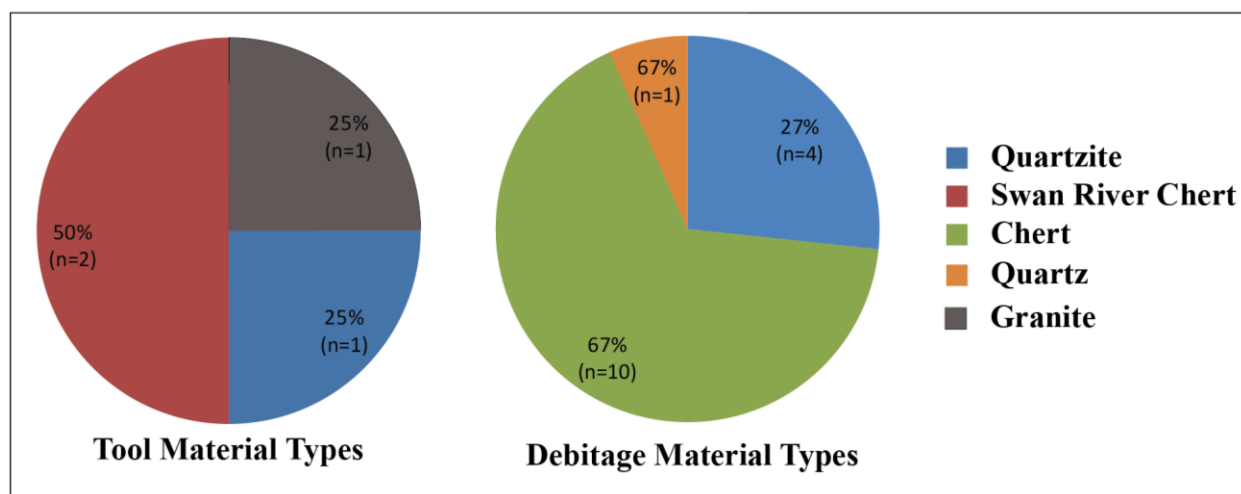


Figure 5.2-5. Summary of lithic material types recovered from EkNj-68.

Fifteen pieces of lithic debitage with a total mass of 1.95 g were recovered from the 0.75 m² excavated of EkNj-68 (Table 5.2-2). Lithic materials of recovered debitage consist of chert (66%; n=10), quartzite (26%; n=4), and quartz (6%; n=1); no exotic lithic materials (that is material which has been imported or traded into the region) were recovered (Figure 5.2-5).

The debitage analysis carried out on this collection is summarized in Table 5.2-3 (also see Appendix B2). The debitage consists primarily of small flakes less than 1 cm in maximum dimension with 80% falling into the 0.5 to 1.0 cm size range (n=12). The majority of flakes recovered consisted of block shatter/debris (47%; n=7), followed by broken flakes (33%; n=5) and complete flakes (20%; n=3). Hard hammer/reduction flakes made up 53% of the flake types recovered (n=8), with pressure/finishing flakes making up 27% (n=4) of the collection and cortical flakes accounting for 20% (n=3).

The lithic debitage recovered from the site suggests that lithic reduction was likely primarily focused on earlier stages of reduction than observed at EkNj-4 and EkNk-3 based on a higher percentage of reduction and cortical flakes than retouch/finishing flakes, although the majority of the debitage was small (less than 1cm). The absence of exotic raw lithic material may also suggests a reliance on locally available lithic resources.

Table 5.2-3. Summary of debitage recovered from EkNj-68.

Flake Size (cm)				
<0.1 0%	0.1-0.25 0%	0.25-0.5 13%	0.5-1.0 80%	>1.0 7%
Flake Completeness				
Complete Flakes 20%	Broken Flakes 33%	Flake Fragments 0%	Debris 47%	Split Flakes 0%
Flake Type				
Biface Thinning Flakes 0%	Hard Hammer/Core Reduction Flakes 53%	Pressure/Finishing Flakes 27%	Bipolar Flakes 0%	Cortical Flakes 20%

5.2.2.2 Paleobotanical Remains

During excavation, one soil matrix sample was collected from the hearth which was processed through flotation (Table 5.2-4). The sample yielded charcoal and seeds; a brief inventory of recovered paleobotanicals is outlined in Table 5.2-5. Macroremains recovered from these samples included *Chenopodium* sp. (goosefoot), *Polygonum* sp. (knotweed), *Trifolium* sp. (clover), *cf.*, *Mentzelia* (sand-lily), an unknown seed, and unidentifiable seeds. Charcoal fragments were not large enough to allow for identification.

Table 5.2-4. Matrix samples subject to flotation and paleobotanical analysis from EkNj-68.

Sample	Unit	Level	Depth Below Surface (cm)	Unit Provenience (cm)	Volume (ml)	Context of Collection
1	S75	2	12-15	0-30 E, 70-100 N	2000	Hearth

Table 5.2-5. Summary of paleobotanical plant taxa* recovered from EkNj- 68.

Taxon	Common Name	Plant part(s)	Tally
<i>Chenopodium</i> sp.	Goosefoot sp.	Seed	1
<i>Polygonum</i> sp.	Knotweed sp.	Seed	1
<i>Trifolium</i> sp.	Clover sp.	Seed	1
cf., <i>Mentzelia</i>	Compares favourably with Sand-Lily	Seed	2
Unknown seed		Seed	1
Unidentified seed fragments		Seed	2
Charcoal		Stems, twigs	71
Charcoal fragments		Unknown	207

*Only recovered charred macroremains are presented in this table.

5.2.3 Radiocarbon Dates

One sample recovered from the matrix sample collected at EkNj-68 was sent to the A.E. Lalonde AMS Laboratory at the University of Ottawa for analysis. This sample included only the charcoal fragments recovered from matrix sample 1: EkNj-68:C1 (Tables 5.2-4 and 5.2-6).

Given the ephemeral nature of the excavated hearth deposits at this site, it is possible that it was only fired once and therefore the date obtained may reflect a single use event. Charcoal fragments included grasses, stems, and twigs produced during a single season of growth. See Appendix D for further details.

Table 5.2-6. Charcoal samples from EkNj-68 subject to AMS radiocarbon analysis.

Sample	Unit	Level	Depth Below Surface (cm)	Unit Provenience (cm)	Mass (mg)	¹⁴ C yr BP	Calibrated year AD
EkNj-68:C1	S75	2	12-15	0-30 E, 70-100 N	70	121 ± 22	1681-1954

5.2.4 EkNj-68 Summary

Results of the excavation carried out at EkNj-68 date this site to the protocontact period based on the radiocarbon analysis of charred organics recovered from the hearth. Of the area excavated adjacent to ring Feature 11, recovered cultural materials include one utilized flake, one retouched flake, 15 pieces of lithic debitage, one hammerstone, one polishing stone, and one piece of ochre pigment. In addition, recovered paleobotanicals, including seeds of *Chenopodium* sp. (goosefoot), *Polygonum* sp. (knotweed), *Trifolium* sp. (clover), cf., *Mentzelia* (sand-lily), provide a glimpse of the plant life at the site. See Chapter 7 for discussion and interpretation of the excavation results.

5.3 EkNk-3

Archaeological site EkNk-3 is a precontact multiple feature site located approximately 400 m from the western end of Little Manitou Lake and 500 m from Waterman Marsh to the west, a freshwater marsh which drains into Little Manitou Lake via a channel to the north of the site (Figures 5-1 and 5.3-1). The site, which sits at 501 m asl, just above the modern lake level of approximately 493 m asl, consists of 14 stone circles and one rock cairn and measures 260 m (N-S) x 270 m (E-W) (Kenny 1985; Rescan 2011). The area selected for detailed investigation focused on an area roughly in the centre of the site at a cluster of stone circles (Figure 5.3-2).

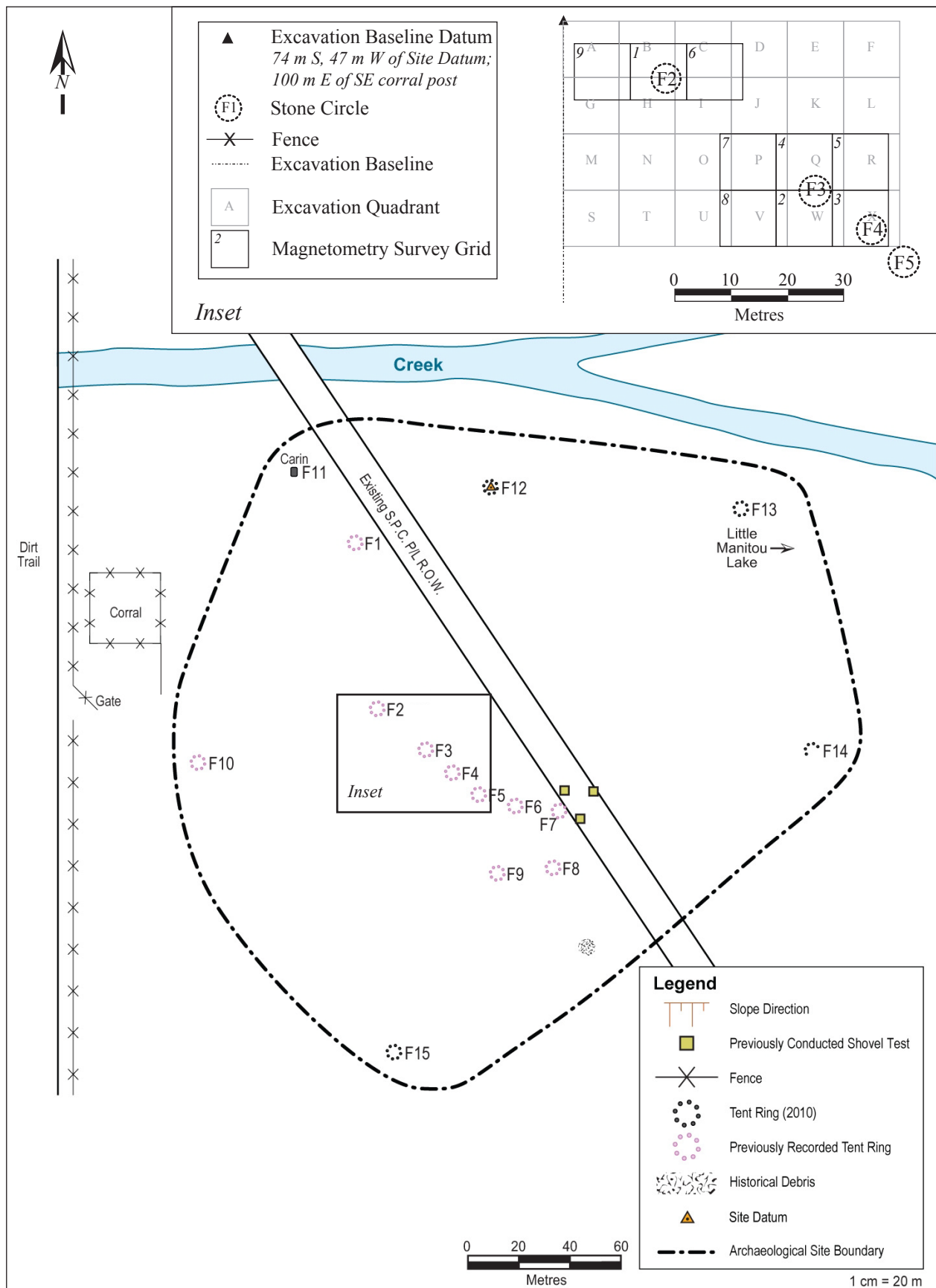


Figure 5.3-1. View south-southwest toward EkNk-3 (roughly delineated by yellow oval). Little Manitou Lake to left, Waterman Marsh to right.

5.3.1 Magnetometry, Feature Mapping, and Magnetic Susceptibility

Magnetometry surveys were carried out over three stone circle features (Features 2, 3, and 4). All rocks within each 10 x 10 m magnetometry grid were mapped and their locations correlated with magnetic anomalies. These results were used to identify a target area adjacent to Feature 2 for subsurface investigation (Figure 5.3-3; see Appendix A3 for detailed magnetometry maps for all other stone circle features).

Matrix samples were collected from a hearth feature identified during subsurface investigations outside and adjacent to ring Feature 2, and a column sample was taken from an area north of ring Feature 2 where magnetic anomalies were absent (as documented by magnetometry surveys; Figure 5.3-3). Soil from the matrix and column samples was subject to post-excavation magnetic susceptibility analysis (see Section 4.3.2.2 for further details), the results of which are presented in Table 5.3-1.



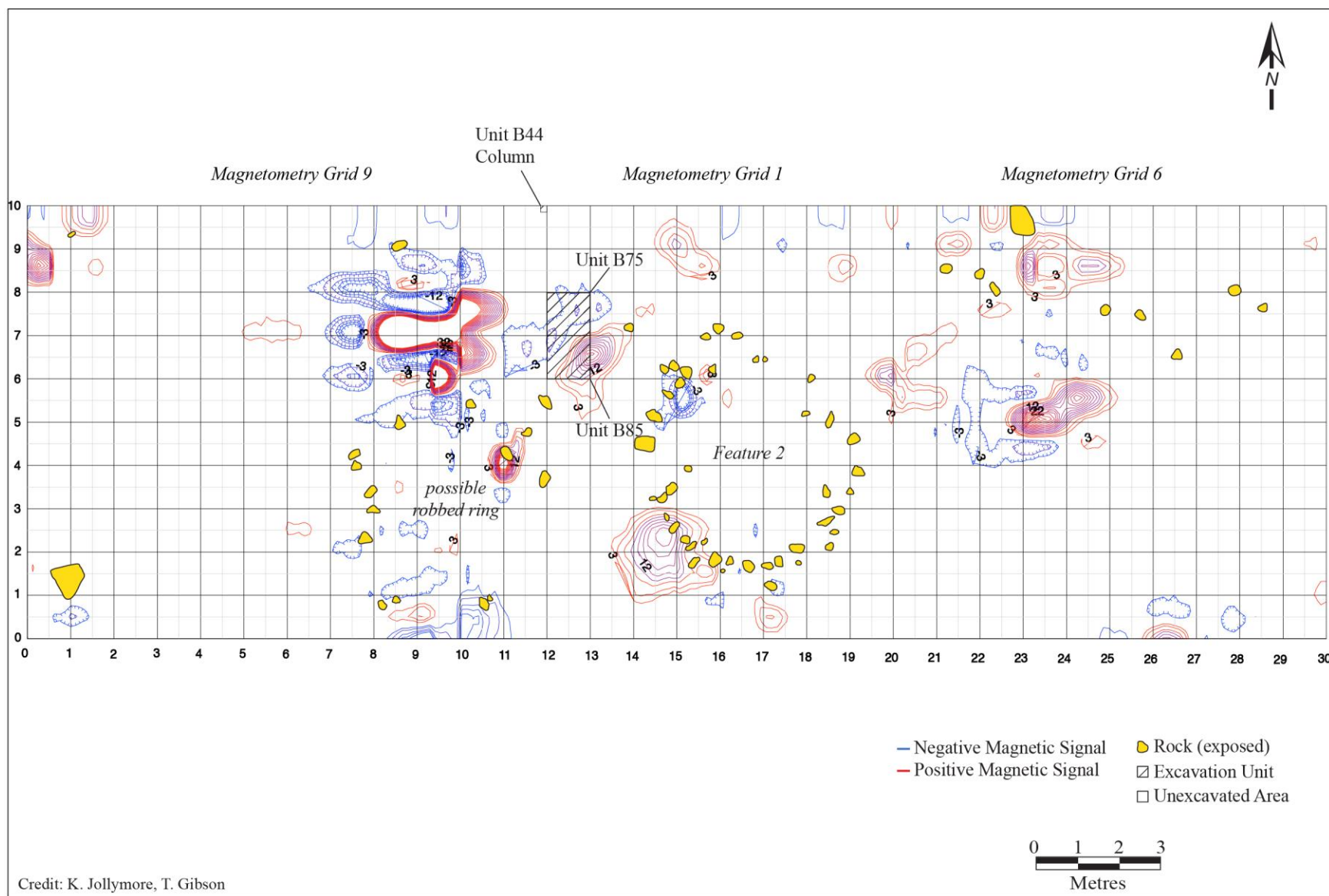


Figure 5.3-3. Results of magnetometry Grids 1, 6, and 9 and mapped rocks for EkNk-3 Feature 2 and adjacent areas, column sample from unit B44, and excavation units B75 and B85. Magnetic data shown in 1nT intervals, starting at -3/3 nT, with intervals beyond -10/10 nT suppressed.

Table 5.3-1. Results of magnetic susceptibility evaluations carried out on matrix samples from EkNk-3.

Sample	Unit	Level	Depth Below Surface (cm)	Unit Provenience (cm)	Mass (g)	Context of Collection	KT-10 Harmonized to 20 g (SI units)
1	B85	2	7-10	65-100 E, 70-100 N	30	Top of hearth.	0.137
7	B75	3	10-11	70-80 E, 45-55 N	20	Area of burning adjacent to hearth.	0.067
8	B75	4	15-16	80-100 E, 0-20 N	20	Hearth.	0.092
9	B75	5	20-25	70-100 E, 5-25 N	30	Hearth.	0.079
12	B85	2	8-10	40-55 E, 25-40 N	20	Area of burning adjacent to hearth.	0.119
13	B85	3	10.5-12	23-40 E, 30-45 N	20	Area of burning adjacent to hearth.	0.079
14	B85	7	30-33	80-90 E, 90-100 N	20	Beneath hearth.	0.245
8a	B44	1	0-5	90-100 E, 90-100 N	20	Column	0.148
8b	B44	2	5-10	90-100 E, 90-100 N	20	Column	0.140
8c	B44	3	10-15	90-100 E, 90-100 N	20	Column	0.141

5.3.2 Excavation Results

As noted earlier in this thesis, by design only a small area at this site was targeted for excavation with the express purpose of locating hearth deposits, resulting in a total area of 2.0 m² excavated at EkNk-3. Due to the small excavation area, it should be noted that recovered cultural material may not be representative of the entire stone circle which was under investigation. However, while not necessarily representative of the whole ring, because excavations focused on hearth deposits, which have been suggested to have been used as waste receptacles, recovered cultural material may still represent a broader picture of the artifact record at this ring than might be expected for similar sized excavation areas that are not located on hearth features.

Units excavated at the site were: B75 and B85, both adjacent to ring Feature 2. Excavations were carried out in 5 cm arbitrary levels. These excavations resulted in the identification of a hearth feature (Figure 5.3-4). In total, one retouched flake, one utilized flake, 33 pieces of lithic debitage (4.45 g), one pebble polishing stone, one piece of talc pigment, one internal carpal of *Bison* sp. (right side), and two birdshot pellets were recovered from EkNk-3 (Table 5.3-2 and discussed further below). In addition, shells of *Valvata tricarinata* (n=254), *Stagnicola caperata* (n=136), and *Gyraulus parvus* (n=37) were recovered below the cultural levels (Section 5.3.2.2). See Appendices B3 and C3 for additional details.

Soil at the site is a Vertic Black Chernozem, a nutrient rich soil that occurs in association with native vegetation of mesophytic grasses and forbs. This subgroup differs from other subgroups within the Black Chernozemic Great Group by having properties that are indicative of integrating with the Vertisolic Order (Soil Classification Working Group 1998). While this soil

type does not meet the qualifications of the Vertisolic Order, it can exhibit slickenside horizons due to the soils tendency to shrink and swell. This vertic action results in the opening of cracks which can allow materials from the surface or soil particles along the walls of the cracks to fall down into deeper locations (Holliday 2004).

Table 5.3-2. Summary of artifacts recovered from EkNk-3.

Artifact Type	Quantity (n=x)	Percentage of Collection (%)
Lithic debitage	33	82.50
Retouched flakes	1	2.50
Utilized flakes	1	2.50
Polishing stone	1	2.50
Pigment	1	2.50
Faunal remains	1	2.50
Ammunition	2	5.00
Total	40	100

The site falls within an area assigned as soil unit Wr4:1 of the Weyburn soil association, 3h a designation assigned during soil mapping carried out by the R.M. of Viscount (Saskatchewan Soil Survey 1990). However, more recent soil mapping suggests that the soil association for the site area is more consistent with the Weyburn-Elstow soil complex (Rescan 2012a). This complex consists of a dark brown soil formed in a mixture of loamy glacial till (Weyburn) and shallow, silty lacustrine materials (Elstow) resulting in loam to clay loam (WrEw) surface textures which occur on hummocky landscapes with gentle to moderate slopes (Rescan 2012a; Saskatchewan Soil Survey 1990).

Before outlining the observed soil profile from this site, the reader should note that two interpretations for the hearth identified at this site have been proposed (surface vs. basin). The surface hearth interpretation is based on portable optically-stimulated luminescence (POSL) analyses of samples taken from the site. The basin-shaped hearth interpretation draws on observations made during excavations and recovered cultural material; the soil stratigraphy noted below is based on these observations. Both interpretations are presented below following the soil profile descriptions.

The soil profile for areas excavated at the site consists of a very dark brown (10YR 2/2) stratum of littermat and loam (stratum Ia), a very dark brown (10YR 2/2) stratum of loamy clay with gravel which exhibits vertic characteristics (stratum Ia), a dark yellowish brown (10YR 4/4) stratum of clay containing charcoal flecks and spots of reddened burnt soil denoting the location of a hearth (stratum IIa), a dark yellowish brown (10YR 4/4) stratum of compact clay (stratum

I Ib), a light grey (10YR 7/1) stratum of ashy silt (IIc), a very pale brown (10YR8/2) lens of sandy silt (only observed in the southern wall of unit B75) (stratum IId), a pale yellowish brown (10YR 6/4) stratum of silty clay with fine gastropod shells (stratum III) (see Section 5.3.2.3), and a pale brown (10YR 6/3) stratum of silty clay and large boulder (stratum IV) (Figure 5.3-4 and Appendix C3).

Stratum I (Ia and Ib) is generally shallow, laying between 0 and 10 cm depth below surface (DBS). Stratum II (IIa through IId) ranges between 5 and 30 cm DBS. Cultural material was confined to the strata Ia, Ib, IIa, and IIb. Stratum Ib denotes soil exhibiting slickenside characteristics where vertic action has occurred, in some cases extending beyond the ~30 cm maximum excavated depth. The distinction between where stratum Ia and Ib intersect was difficult to see as both are very dark making differentiation based on soil colour difficult to achieve. Stratum IIa denotes anthropogenic hearth deposits while IIc denotes an ashy lens observed at the bottom of the hearth; both are described further below. Stratum III is a silty clay stratum in which small shells were recovered. Cultural material was recovered from the interface between this stratum and those overlying it. Only two small pockets of the sandy silt lens (IId) were observed, both in the wall adjoining units B75 and B85 (see Appendix C2).

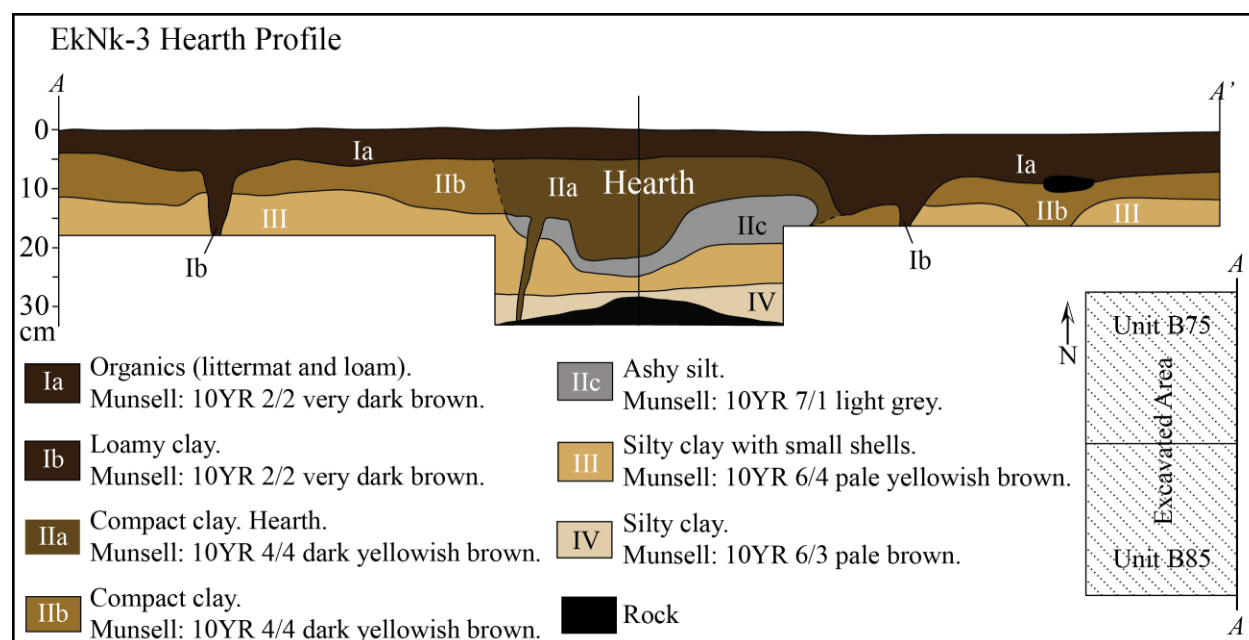


Figure 5.3-4. Profile of eastern walls of excavation units at EkNk-3 illustrating hearth deposits.

Like both EkNj-4 and EkNj-68, some of the rocks and pebbles present in the soil at this site are of types often used for the manufacture of stone tools, such as tan/beige coloured chert

and Swan River chert. To differentiate between natural and cultural lithic material, lithics of these material types collected during excavation were subject to inspection under a Kyowa Optical Model SDZ-P dissecting stereomicroscope (7 - 45 x magnification) to verify the presence or absence of typical cultural modifications.

As noted above, two interpretations for the hearth identified at this site have been proposed: surface vs. basin hearth. Both interpretations are presented here for completeness.

Surface Hearth

POSL analysis was carried out on two sets of samples collected from EkNk-3: one set from the hearth in the eastern wall of Unit B75 and a second set collected from the northern wall of the same unit (see Appendix C3). The results and interpretation of these samples were carried out by Dr. Krista Gilliland of Western Heritage Services Ltd. and are presented in Appendix E. The interpretation of the POSL profiles was primarily conducted through visual examination of charted numerical data and photographs of site stratigraphy. The sample from the hearth in the eastern wall was taken to evaluate the depositional history of the hearth while the sample from the north wall was taken from a culturally quiet area of the unit to act as baseline data for general soil deposition at the site.

For the hearth wall profile, Dr. Gilliland postulated a gradual deposition in the lowest part of the profile between Samples 8 and 7 (35-27 cm) followed by rapidly deposited sediment between Samples 6 to 3 (27-14 cm DBS). Gradual deposition occurred in the upper 7 cm of the stratigraphy where the photon counts between Samples 3 to 1 (14-3 cm DBS) suggest deposition breaks or very slow deposition which may represent multiple occupations; the OSL depletion ratio corroborate the depositional history for these samples (see Appendix E). Based on these findings, Dr. Gilliland suggests that although a bowl-shaped feature was observed during excavation, the hearth was not dug out and subsequently filled with redeposited sediment but rather the bowl shape appears to represent discoloration resulting from burning at the former surface during site occupation resulting in discoloration of underlying sediments (similar instances of this have been observed at the FM Ranch site - EfPk-1 [Gilliland et al. 2016]). She also suggests that artifact recoveries did not follow the colouring (being between 0 and 15 cm DBS) and that stratigraphically the compaction appears to be uniform throughout the unit (Dr. Krista Gilliland, personal communication 2016).

The eastern hearth wall results were then compared with the north non-hearth wall POSL results where similar depositional signatures were observed, although the hearth signatures had a consistently reduced number of photon counts relative to the north wall. This was puzzling as one would expect enhanced quartz sensitivity during heating and therefore a higher POSL signal (Dr. Krista Gilliland, personal communication 2016). This could potentially be explained by wall exposure and sampling discrepancies with samples being collected from a wall which was not adequately cleaned back prior to sampling. Although the wall had been exposed during four days of excavations, it was scraped back before sampling and the samples taken in low-light conditions (dusk) (see Section 4.3.4).

Basin Hearth

The basin-shaped hearth feature encountered during excavations was identified by the observed presence of charcoal, blackened soil, some reddened burnt soil, fire broken rock, and an ash lens (Figure 5.3-4). The hearth was found in Units B75 and B85 and appears to extend further east into unexcavated Units B76 and B86. Based on the general dimensions of the excavated portion of the hearth, it is believed that approximately half of the hearth has been excavated in the southeast quadrant of Unit B75 and the northeast quadrant of Unit B85. The overall dimensions of the excavated portion of the hearth are 27 cm E-W by 50 cm N-S. The hearth appeared as a stratum of burnt soil (anthropogenic strata IIa). At its deepest point, the hearth measures 20 cm thick (5 cm to 25 cm DBS), including the ash lens at its base. Three matrix samples, each from distinct depths, were collected from the hearth and floated (see Section 5.3.2.4 and Table 5.3-4). Charcoal recovered from matrix samples 9 and 10 were subject to radiocarbon dating returning dates for material recovered between 7 and 10 cm DBS, the top of the hearth, and between 20 and 25 cm DBS, the bottom of the hearth. Fire broken rock was recovered with burnt soil in Unit B85 between 3 and 10 cm DBS. Three pieces of lithic debitage and one retouched flake were recovered from the hearth. One piece of faunal material, a bison carpal (EkNk-3:44), was also recovered immediately adjacent to the hearth; it does not show signs of burning or cut marks indicative of butchering (Section 5.3.2.2).

Although the POSL interpretation provides data which helps to explain soil deposition at the site through time, there are several points which are difficult to reconcile. Charcoal and charred organics were recovered throughout the discolored section (or basin) of the hearth. If the

feature observed at this site was a surface hearth, one would not expect to find charcoal and charcoal stained soil below the area of burning, although it is possible that multiple occupations occurred at this site. Charcoal recovered from the bottom of the basin hearth may represent an early use of the site while fire broken rock and reddened soil (only observed between 3 and 10 cm DBS) may represent a surface hearth used during a latter occupation. Further excavations at the site and additional POSL sampling could help to verify this supposition.

5.3.2.1 Lithic Material

Three stone tools were recovered from the 2.0 m² excavated at EkNk-3 (Table 5.3-2). These artifacts consist of one retouched flake, one utilized flake, and one polishing stone. No diagnostic points or formed tools were recovered. The retouched flake is made of Swan River Chert, the utilized flake is made of quartzite, and the polishing stone is also made of quartzite (Figure 5.3-5). In addition one piece of talc pigment was recovered, although it is unclear whether it is of cultural significance. See Appendix C3 for artifact photographs and catalogue.

Thirty-three pieces of lithic debitage with a total mass of 4.45 g were recovered from the 2.0 m² excavated at EkNk-3 (Table 5.3-2). Raw lithic materials of recovered debitage consist of quartzite (42%; n=14), chert (24%; n=8), fine-grained quartzite (18%; n=6), siltstone (6%; n=2), quartz (6%; n=2), and Swan River Chert (3%; n=1) (Figure 5.3-5).

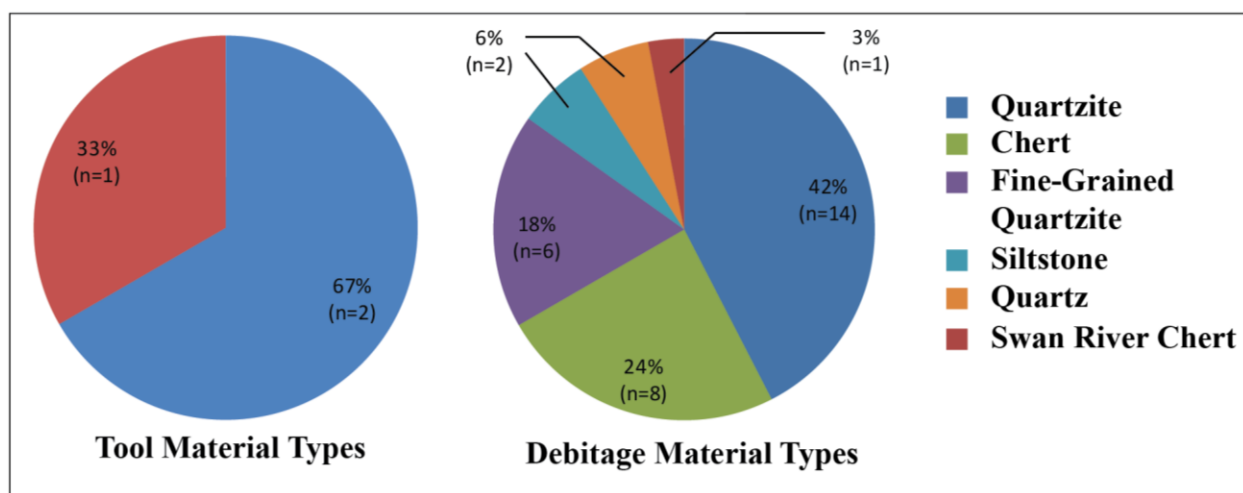


Figure 5.3-5. Summary of lithic material types recovered from EkNk-3.

The debitage analysis carried out on this collection is summarized in Table 5.3-3. The majority of debitage consists of small flakes less than 1 cm in maximum dimension with 61% falling into the 0.5 to 1.0 cm size range (n=20). The majority of flakes recovered consisted of

block shatter/debris (52%; n=17), followed by broken flakes (27%; n=9), complete flakes (18%; n=6) and split flakes (3%; n=1). Biface thinning flakes and pressure/finishing flakes made up the majority of the flake types recovered (33% and 30%, respectively), with hard hammer/reduction flakes making up 15% of the collection and cortical flakes accounting for 21%.

The lithic debitage recovered from the site suggests that lithic reduction was likely primarily focused on late-stage shaping/resharpening rather than earlier stages of lithic reduction. The absence of exotic raw lithic material (that is material which has been imported or traded into the region) may also suggests a reliance of locally available lithic resources.

Table 5.3-3. Summary of debitage recovered from EkNk-3.

Flake Size (cm)				
<0.1 0%	0.1-0.25 3%	0.25-0.5 12%	0.5-1.0 61%	>1.0 24%
Flake Completeness				
Complete Flakes 18%	Broken Flakes 27%	Flake Fragments 0%	Debris 52%	Split Flakes 3%
Flake Type				
Biface Thinning Flakes 33%	Hard Hammer/Core Reduction Flakes 15%	Pressure/Finishing Flakes 30%	Bipolar Flakes 0%	Cortical Flakes 21%

5.3.2.2 Faunal and Shell Remains

One piece of bison bone, a right-side internal carpal, was recovered during excavations from level 2 in unit B85 at the edge of the hearth feature (see Figure 5.1-4; Appendix C3 for hearth plan view). The bone is somewhat gracile and as such may suggest a female bison (Dr. Ernie Walker, personal communication September 2015).

Shells of three different gastropod species were also recovered from the site: *Valvata tricarinata*, *Stagnicola caperata*, and *Gyraulus parvus* (Figure 5.3-6; Clarke 1981). All shell was recovered immediately below the cultural level and are not considered cultural. While these shells are not cultural in origin, they do provide insight into the local environment prior to site occupation.

Valvata tricarinata (Three-keeled Valve Snail) was by far the most prevalent species recovered (n=254). This species is found across Canada from New Brunswick to eastern British Columbia and south of the northern tree line (tundra-boreal forest) in the Northwest Territories. They only occur in perennial lakes, rivers, streams, and muskeg pools, and among vegetation;

they are rare in ponds (Clarke 1981). This species can tolerate extremely high levels of alkalinity (Cvancara 1983).

Stagnicola caperata (Blade-ridged Stagnicola) was the second most prevalent species recovered (n=136). They are a typical prairie species with a range from southern Manitoba to southern and central Alberta. This species is most commonly found in temporary-water habitats, such as ditches and shallow pools, or in spring-flooded margins of permanent-water habitats. Rarely, they occur in large permanent lakes, rivers, and swamps. This species can tolerate highly saline waters (Cvancara 1983).

Gyraulus parvus (Modest Gyraulus) was the least prevalent species (n=37). This species has a wide distribution across Canada south of the northern tree line (tundra-boreal forest). They are typically an abundant species which lives on submersed aquatic vegetation in all types of permanent or temporary water-filled habitats where the bottom is muddy. This species can tolerate extremely high levels of alkalinity (Cvancara 1983).

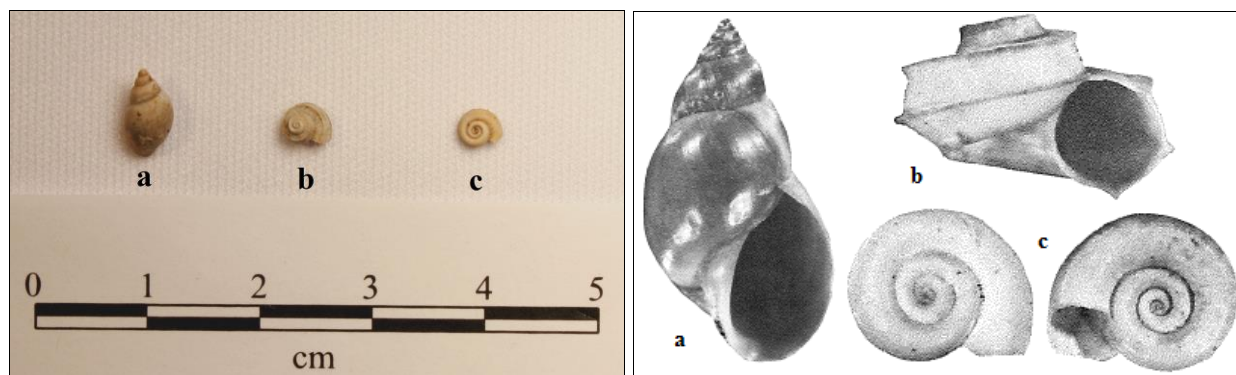


Figure 5.3-6. Shells of snail species recovered from EkNk-3 and images after Clarke (1981): a. *Stagnicola caperata*, b. *Valvata tricarinata*, and c. *Gyraulus parvus*.

5.3.2.3 Historic Material

Two pieces of lead shot were recovered during excavation. Both pieces were recovered from the sod layer (the top 2 cm of level 1) of unit B85. One piece is a No. 4 (0.13"/0.33 mm) birdshot pellet and the other is a No. 2 (0.15"/0.39 mm) birdshot pellet (see Figures 5.1-6 and 5.1-7; Barnes 2000).

The area is well known for autumn duck hunting as Little Manitou Lake is habitually used by migrating duck and game bird species (see Section 2.3.1). Both No. 2 and 4 birdshot pellets are typically used for duck hunting as it allows the hunter to kill a number of birds in one shot; No. 4 birdshot has been especially popular for long-range waterfowl hunting (Barnes

2000). Since both pieces of shot were recovered from the near-surface in the sod layer it is likely that they postdate occupation of the site and therefore will not be discussed further.

5.3.2.4 Paleobotanical Remains

During excavation, three soil matrix samples were collected which were processed through flotation (Table 5.3-4). All samples yielded charcoal and seeds; an inventory of recovered paleobotanicals is outlined in Table 5.3-5. Macroremains recovered from these samples included *Chenopodium* sp. (goosefoot), *cf.*, *Scirpus* (bullrush), *cf.*, *Mammillaria* (cactus), *cf.*, *Aster* (aster/daisy), *cf.*, *Panicum* (panicgrass), Poaceae (grass family), and unidentifiable seeds. One piece of charcoal was identified as *Alnus* sp. (alder). The small size of the remaining charcoal fragments preclude their identification. Two pieces of charcoal were also recovered from the screen during excavations, identified as *Alnus* sp. (alder).

Shells of *Valvata tricarinata* (n=36), *Stagnicola caperata* (n=22), and *Gyraulus parvus* (n=8) were recovered from the heavy fraction of sample 11; this material has been included in the artifact catalogue and the total number of shell summarized in Section 5.3.2.2.

Table 5.3-4. Matrix samples subject to flotation and paleobotanical analysis from EkNk-3.

Sample	Unit	Level	Depth Below Surface (cm)	Unit Provenience (cm)	Volume (ml)	Context of Collection
9	B75 (&B85)	5	20-25	70-100 E, -5-25 N	2000	Bottom of hearth
10	B85	2	7-10	65-100 E, 70-100 N	2000	Top of hearth
11	B85	3	13-15	0-40 E, 30-50 N	1600	Hearth

5.3.3 Radiocarbon Dates

Charcoal recovered from matrix samples taken at EkNk-3 was sent to the A.E. Lalonde AMS Laboratory at the University of Ottawa for analysis. The samples included charcoal fragments recovered from matrix samples 9 and 10: EkNk-3:C9 and EkNk-3:C10 (Tables 5.3-4 and 5.3-6). The date from sample C9 likely represents the maximum date of use for this feature since it was obtained from the bottom of the hearth. Conversely, the date from sample C10 returned a modern date; given the shallowness of the sample it likely reflects charcoal deposited in the recent past as a result of grass fires or other recent burning events. Charcoal fragments included grasses, stems, and twigs produced during a single season of growth. Some small charred bark fragments were observed in the samples which were removed prior to analysis. The

volume of charred material recovered from matrix sample 11 was insufficient for AMS analysis. See Appendix D for further details.

Table 5.3-5. Summary of paleobotanical plant taxa* recovered from EkNk-3.

Taxon	Common Name	Plant part(s)	Tally (by Matrix Sample)	Present in Matrix Sample
<i>Chenopodium</i> sp.	Goosefoot sp.	Seed	4 6 5	9 10 11
cf., <i>Scirpus</i>	Compares favourably with Bullrush	Seed	2	9
cf., <i>Mammillaria</i>	Compares favourably with Cactus	Seed	1	9
cf., <i>Aster</i>	Compares favourably with Aster (part of the Daisy family)	Seed	3	9
cf., <i>Panicum</i>	Compares favourably with Panic Grass	Seed	2	10
<i>Polygonum</i> sp.	Knotweed sp.	Seed	1	11
Poaceae	Grass	Seed	11	11
Unknown seed - likely Poaceae	Likely grass	Seed	1 6	9 10
Unidentifiable seed /seed fragment		Seed	31 7	10 11
Charcoal - <i>Alnus</i> sp.	Alder	Twigs	1 1	10 Screen - Unit B85, Level 1, NW quadrant
Charcoal fragments - Unidentified		Unknown (grass, wood, stems, twigs, etc.)	96 301 193	9 10 11

*Only recovered charred macroremains are presented in this table.

Table 5.3-6. Charcoal samples from EkNk-3 subject to AMS radiocarbon analysis.

Sample	Unit	Level	Depth Below Surface (cm)	Unit Provenience (cm)	Mass (mg)	¹⁴ C yr BP	Calibrated year AD
EkNk-3:C9	B75	5	20-25	70-100E, -5-25 N	30	326 +/-34	1472-1645
EkNk-3:C10	B85	2	7-10	65-100 E, 70-100 N	50	Modern	1954-1956

5.3.4 EkNk-3 Summary

Results of the excavation carried out at EkNk-3 date this site to the Late Precontact or early Protocontact period based on the radiocarbon analysis of charred organics recovered from the hearth. Of the area excavated adjacent to ring Feature 2, recovered cultural materials include one retouched flake, one utilized flake, 33 pieces of lithic debitage, one pebble polishing stone, one piece of talc pigment, and one internal carpal from the right side of a *Bison* sp. In addition, recovered identifiable paleobotanicals (including seeds of *Chenopodium* spp. (goosefoot), cf., *Scirpus* (bullrush), cf., *Mammillaria* (cactus), cf., *Aster* (aster/daisy), cf., *Panicum* (panicgrass),

Poaceae (grasses) and charcoal of *Alnus sp.* (alder)) provide a glimpse of the plant life at the site. Shells of aquatic snails *Valvata tricarinata*, *Stagnicola caperata*, and *Gyraulus parvus* were also recovered immediately below the cultural level. These species can tolerate hypersaline water conditions and are typically found in semi-permanent waterbodies, indicating that the site was likely inundated by shallow salty water prior to site occupation. See Chapter 7 for discussion and interpretation of the excavation results.

5.4 Chapter Summary

This chapter presents the findings from magnetometry surveys, excavations, and analyses of recovered cultural materials from EkNj-4, EkNj-68, and EkNk-3. The magnetometry surveys were successful in locating potential hearth locations and subsequent excavations at all three sites resulting in the discovery of hearths which in turn produced charred organics and identifiable paleobotanicals. The analysis of charred organics from these sites provided absolute dates placing site occupation during the Late Precontact and Protocontact periods.

No formed or diagnostic tools were recovered from any of the sites, however, all sites produced expedient tools and lithic debitage made from locally available lithic resources. Interestingly, all sites contained hammerstones and polishing stones. Pigment was also recovered from each site: ochre from EkNj-4 and EkNj-68 and talc from EkNk-3 - although whether the presence of this material is of cultural or natural origin is unclear.

Faunal material recovered from these sites consisted of fragments of ungulate (likely *Bison sp.*) from EkNj-4 and a *Bison sp.* carpal from EkNk-3. Snail shells were also recovered from EkNk-3 immediately below the cultural level suggesting that the site area was inundated by shallow saline water prior to site occupation.

Of the recovered paleobotanicals, all three sites contained seeds of *Chenopodium spp.* (goosefoot) and grasses, and EkNj-4 and EkNk-3 both contained seeds of *cf., Scirpus* (bullrush) and charcoal from *Alnus sp.* (alder). Other identified macrofossils from these sites include charcoal of *Salix sp.* (willow) from EkNj-4, seeds of *Polygonum sp.* (knotweed), *Trifolium sp.* (clover), and *cf., Mentzelia* (sand-lily) from EkNj-68 and seeds of *cf., Mammillaria* (cactus), and *cf., Aster* (aster/daisy) from EkNk-3.

Both EkNj-4 and EkNk-3 produced lead birdshot pellets. The birdshot recovered from EkNj-4 may be contemporary with the lithic material recovered from the site as it is badly

degraded and the site dates to the Protocontact period when historic material may have been in use. The birdshot recovered from the sod at EkNk-3, however, is likely historic/modern in origin and was not found in association with the lithic material recovered from the site. The area is known for excellent duck hunting during the autumn months and as such, the recovered shot pellets likely relate to such activities.

For further discussion of the excavation results, the reader is referred to Chapter 7.

Chapter 6

Spatial Analyses

The purpose of this chapter is to evaluate spatial parameters of archaeological sites found at the western end of Little Manitou Lake, to help elucidate the cultural landscape. While many of the documented sites in the region suggest residential/domestic use, a handful of sites have been documented as ceremonial in nature. Spatial distributions were evaluated for features within a subset of domestic sites (outlined in Section 4.2.1) and for the placement of ceremonial sites within the broader landscape. Section 6.1 explores spatial attributes for the three domestic sites that were investigated and discussed in Chapter 5 (EkNj-4, EkNj-68, and EkNk-3) while Section 6.2 explores the landscape in which ceremonial sites in this region are situated. Methods used to carry out spatial analyses are summarized in Chapter 4 and in the sections that follow.

6.1 Domestic Site Spatial Analyses

Studies have successfully examined patterning of ring features at stone circle sites to aid in the evaluation of site structure and in some cases contemporaneity (*cf.*, Billeck 1983; Damkjar 2003; Long 2011). As such, the examination of site plans to identify potential spatial patterning was conducted for EkNj-4, EkNj-68, and EkNk-3. In addition, viewshed analyses were carried out to evaluate the extent of the fields-of-view from these sites.

6.1.1 Methods

To test for patterning in stone circle distribution, Average Nearest Neighbor analysis was carried out using the ArcGIS 10.3 toolset. This analysis compares the locational similarities of specified features and generates results identifying spatial patterning as clustered, dispersed, or random (Clark and Evans 1954; Conolly and Lake 2006). Billeck (1983) notes that the underlying assumption of applying nearest neighbor analysis to stone circles sites is that:

the spatial distribution of stone rings is suggested to be related to the number of occupations. If a social distance is maintained in the location of contemporary habitation structures, a relatively uniform

distance between stone rings and a uniform spatial distribution of stone rings might be manifest at a single occupation site [Billeck 1983:2].

He goes on to suggest that the more uniform a pattern, the more likely the circles are from a single occupation. Random or clustered distributions may be the result of single or multiple occupations (Billeck 1983).

The nearest neighbor statistic is calculated by dividing the mean of the observed distance between each point and its nearest neighbor (R_o) by an expected value of R if the distribution was random (R_e):

$$R = \frac{R_o}{R_e} \dots\dots\dots(6.1)$$

The observed distance between each circle and its nearest neighboring stone circle (R_o) is converted into a mean distance:

$$R_o = \frac{\Sigma d}{n} \dots\dots\dots(6.2)$$

where the density (d) of rings (n = total number of rings) is divided by the site area ($A = m^2$):

$$d = \frac{n}{A} \dots\dots\dots(6.3)$$

The expected spacing value (R_e) is calculated by:

$$R_e = \frac{1}{\sqrt{d}} \dots\dots\dots(6.4)$$

The ratio (R) indicates the degree of randomness in the distribution. If R_o and R_e are equal ($R=1$) a random distribution exists, if R is less than 1 (approaching 0 in extreme cases) a clustered distribution exists, and if R is greater than 1 (to a maximum of 2.15) a more regular/dispersed distribution exists (Conolly and Lake 2006).

The significance of R is dependent on the sample size and the density of the point distribution. The variance of mean distances between neighbors in a random distribution is

$$V[R_e] = \frac{4-\pi}{4 \times \pi \times \lambda \times n} \dots\dots\dots(6.5)$$

where n is the number of points and λ is the mean intensity of points. As we can calculate the expected variance, a z-test can be used to test the null hypothesis of random distribution:

$$z = \frac{(R_o - R_e)}{\sqrt{V[R_e]}} \dots\dots\dots(6.6)$$

where z -values of 1.96 or greater indicate significant uniformity, values of -1.96 or lower

indicate a significant tendency toward clustering, and those figures which fall between indicate a significant random patterning (Conolly and Lake 2006).

To provide a visual representation of average proximity between rings and illustrate ring clustering, proximity analysis was also carried out to identifying patterning at these sites as nearest neighbor analysis does not always detect associations (Conolly and Lake 2006:209-211; Damkjar 2003). This was achieved by producing proximity buffers around stone circle centre points using the median distance between neighboring ring features. To accomplish this step, Point Distance (Analysis) was used to extract distances between rings. Only the closest value between features was selected from which the median distance between rings was selected to generate buffers around ring centre points using the Buffer (Analysis) tool.

To evaluate visibility from these sites, viewshed analysis was conducted. Viewshed analysis (or regions of inter-visibility) is concerned with the placement of sites within the landscape and the views across the landscape from those locations using the concepts of field-of-view and line-of-sight (Conolly and Lake 2006; Jones 2006). Field-of-view represents the total visible area from a point on the landscape and line-of-sight refers to the visibility between two points. As such, viewshed analyses produce delineated areas that represent the field-of-view from a given site from which line-of-sight can be determined with any point that falls within the viewshed. The resulting raster outputs display the area(s) visible from a specific point (Jones 2006).

To produce viewsheds, elevation values were extracted from the SGIC DEM raster dataset for archaeological site locations using the Extract Values to Points (Spatial Analyst) and Features to 3D By Attribute (3D Analyst) tools. Once raster values were obtained, site locations were subject to analysis using the Viewshed (Spatial Analyst) tool to produce a viewshed/field-of-view dataset for each site under consideration. Viewscapes from these sites were also ground-truthed during which photographs of the present field-of-view were taken at cardinal and ordinal directions to evaluate modeled results. Vegetation was not included in the model; the results of the model therefore demonstrate the greatest possible range of visibility from the sites.

It was anticipated that the results of the viewshed analysis could be paired with and/or evaluated against directionality of gaps in ring walls since researchers have postulated that gaps in the walls of stone rings can speak to the direction of prevailing winds, preferred viewscapes (facing the interior of the camp or toward the rising sun), or placement of hearths and other

associated features (see Section 3.1.1.2; Banks and Snortland 1995; Day and Eighmy 1998; Long 2011; Moore 1996; Oetelaar 2000; Quigg and Brumley 1984). However, as noted in Section 3.1.1.2, attribute data for stone circles sites have been inconsistently documented over the years and unfortunately, the stone circles sites within the Little Manitou Lake region are no exception. Few archaeological studies prior to 1995 documented data pertaining to gaps in walls (Krozser and Hjermstad 1995) and wall gaps can be difficult to observe. In addition, wall gaps are not always evident (Kehoe 1960:444), particularly in instances where dwellings had elevated doorways to improve the rain seal and deter animal entry, and therefore did not leave a gap in the ring (Adams 1983:8; Kehoe 1983:336).

While ring diameter and the estimated buried depth of stones was documented at EkNj-4, gaps in ring walls were not recorded (Rescan 2011). Similarly, the initial site form and permit report for EkNk-3 included very few details for feature attributes, noting simply "The site consists of at least 10 stone circles ranging in diameter from 4-6 m" (Kenny 1985:Appendix 1); diameter was not assigned to specific features and gaps in ring walls were not considered. When the site was revisited in 2010, four additional rings (and a stone cairn) were documented, for which diameter information was documented for each newly discovered ring. However, no other attributes were recorded and no additional data were documented for the ten previously documented rings (Rescan 2011 and associated SARR form). Wall gap directions were documented for all stone circles at EkNj-68 and the stone circles at EkNj-4 and EkNk-3 which were subject to magnetometry and feature mapping for this thesis. However, as wall gap data remain incomplete for many ring features within the study area, the evaluation of directionality of wall gaps was not explored (due to time and funding constraints these data were not collected for EkNj-4 or EkNk-3).

6.1.2 EkNj-4 Spatial Analysis

For EkNj-4, 41 rings were subject to nearest neighbor analysis (coordinates for ring feature 4 were not available and therefore the feature was eliminated from the analysis; cairns at the site were not included as the intent of this analysis was to evaluate habitation structures only). The site area for the site was 64,857 m² (6.49 ha). Nearest neighbor results were as follows: $R_o = 21.9658$ m; $R_e = 19.8865$ m; and $R = 1.104556$, indicating a random distribution of features at the site (Figure 6.1-1), which might reflect multiple occupations or may be indicative

of large cluster camps which form as irregular arrangements of lodges during periods of aggregation (Banks and Snortland 1995).

A common issue with nearest neighbor analysis is the effect that the size of the study area has on the detection and characterization of patterning (Conolly and Lake 2006). Grouping concentrations of archaeological features can also be problematic, particularly in areas where reuse over time may have occurred, making it difficult to assign specific features to specific use events (Ebert 1992). Because EkNj-4 is quite a large site with some isolated features toward the northern part of the site, there is a chance that these outlying features relate to different occupation events. It has also been argued that sites containing more than five rings likely reflect reuse (Dooley 2002). If this is the case, the overall site area may have falsely inflated site size, which in turn influenced the results of the nearest neighbor analysis, providing only a coarse characterization of settlement patterns at this site.

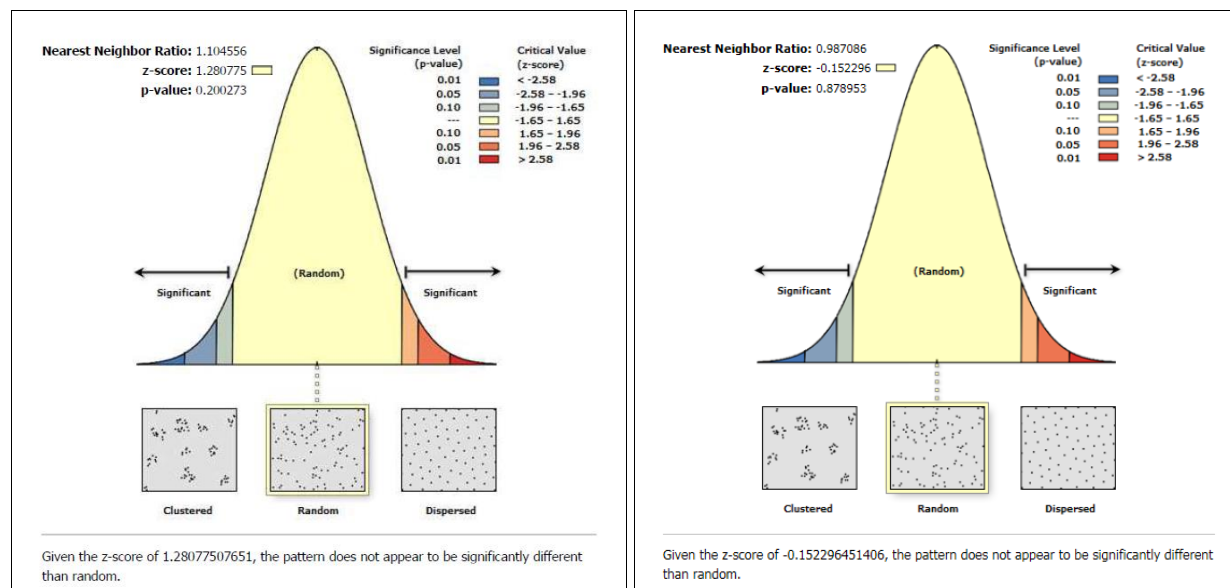


Figure 6.1-1. Results of nearest neighbor analyses for EkNj-4. Left: Site area equal to 64,857 m². Right: Site area equal to 50,929 m² (eliminates Features 1, 2, and 3).

To explore this supposition further, the nearest neighbor analysis was recalculated, this time eliminating three outlying rings at the northern end of the site (Features 1, 2, and 3; see Figure 6.1-3). In this case, the calculated site area was 50,929 m² (5.09 ha) with the nearest neighbor results as follows: $R_o = 18.0683$ m; $R_e = 18.3047$ m; and $R = 0.987086$, indicating a random distribution of features at the site (Figure 6.1-1). Based on the results returned for both calculated site areas (64,857 m² and 50,929 m²), it seems likely that the distribution of rings at

this site is indeed random and therefore could reflect multiple occupations through time.

To aid in reviewing possible patterning not detected in the nearest neighbor analysis, a proximity analysis utilizing the Buffer tool and the Point Distance (Analysis) tool (used to extract distances between rings) were employed. Although the mean distances between rings generated by the nearest neighbor analyses were 21.97 m and 18.06 m, based on the two nearest neighbor analyses respectively, the median distances between rings fell between 16 and 17 m (16.7 when all rings were considered or 16.5 when outlying features were eliminated) (Figure 6.1-2; figures in table rounded to whole numbers). The median distance of 16.5 m was used to create proximity buffers around ring features illustrated in Figure 6.1-3, producing six clusters (with 3 to 9 rings per cluster) and five isolated rings.

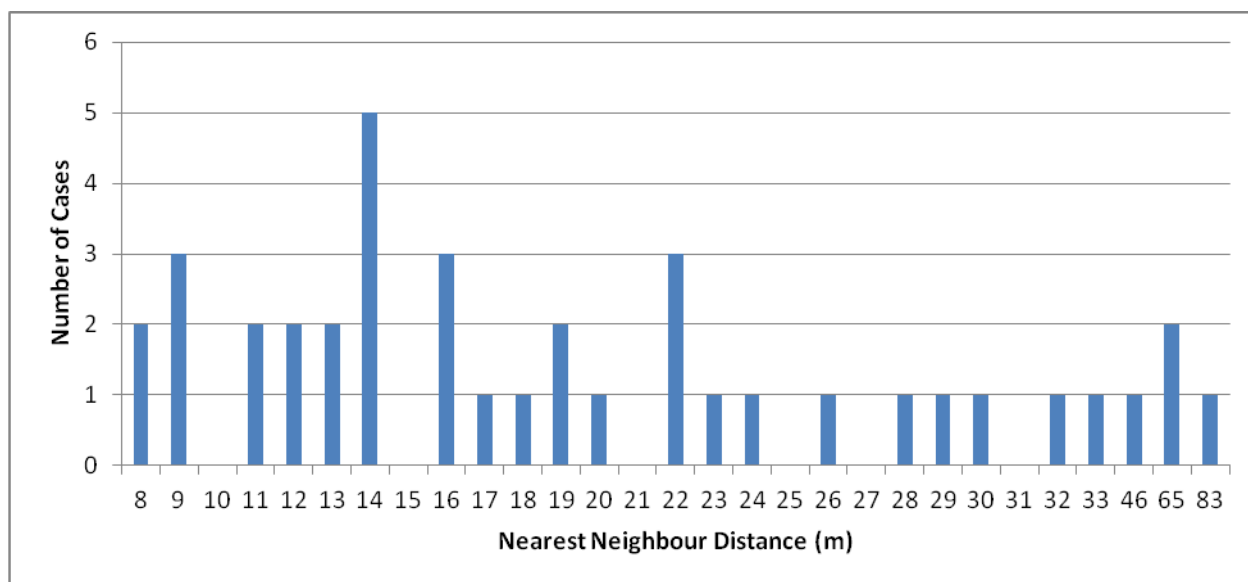


Figure 6.1-2. Distribution of nearest neighbor distances between stone circles at EkNj-4 (note break in consecutive numbering between 33 and 83 m).

Five small clusters of features (ranging between two and nine rings per cluster) are presumed to represent groupings of family units and are likely to be contemporaneous although they could also represent instances of repeated use with features from different use events being placed close to each other (Damkjar 2003; Oetelaar 2003). One linear arrangement of rings was also observed on the west side of the site (features 5, 6, 7, 8, 9, 10, 11, and 12). Linear camps have been suggested to be a Late Precontact/Protocontact phenomenon (Figure 6.1-3; Banks and Snortland 1995; Damkjar 2003). Feature 7 in this linear cluster was subject to limited

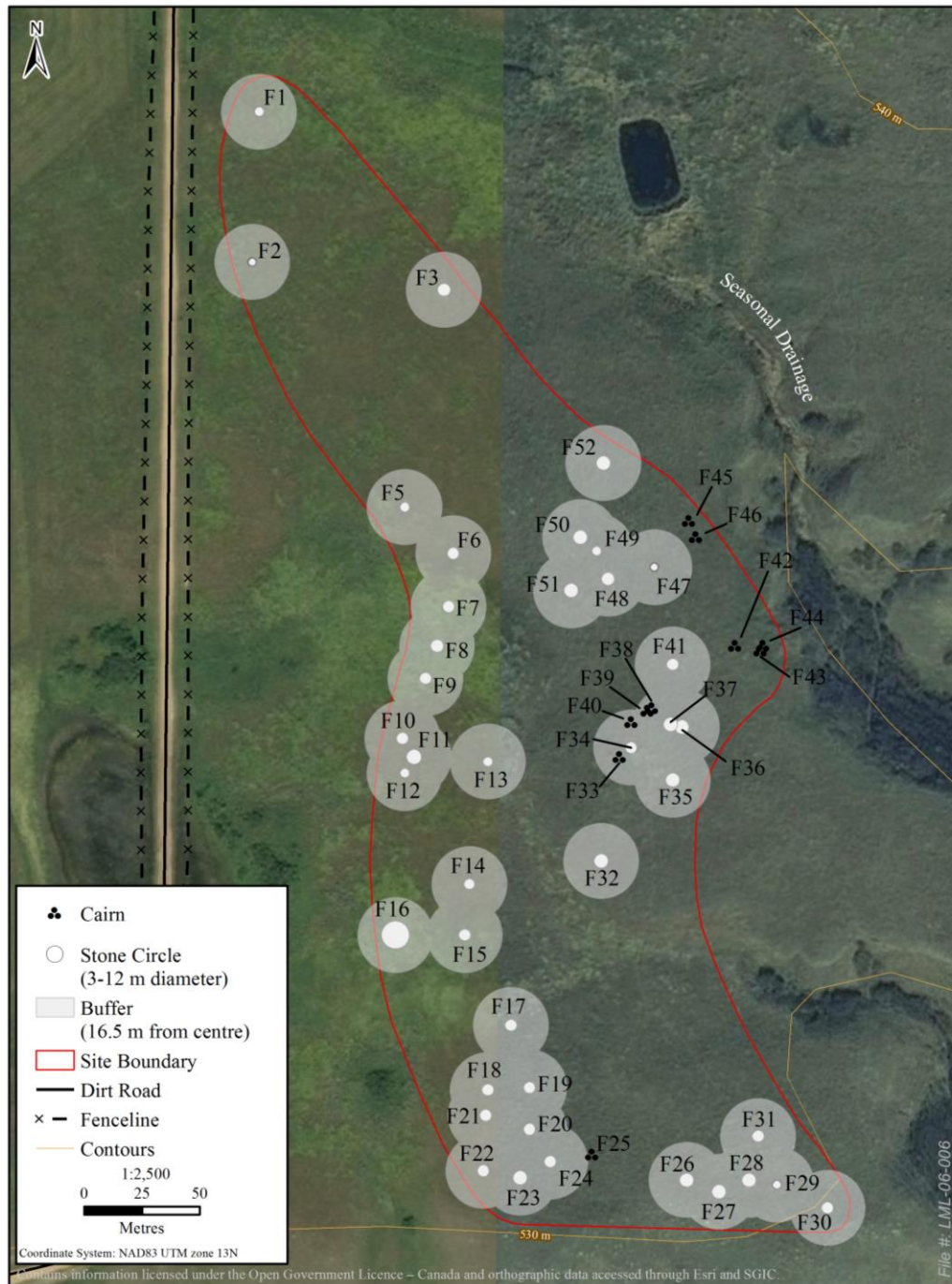


Figure 6.1-3. Site map of features at EkNj-4, illustrating buffered proximity analysis.

excavations producing a date that correlates to the Protocontact period (see Chapter 5), thereby lending support to the interpretation that rings within this cluster may be related to this time period. Without further subsurface investigations at other rings, the ages and contemporaneity of features remains unknown, although it is likely that features within clusters are related. Banks and Snortland (1995:139) also suggest that linear camps may relate to ceremonial activities.

Linear camps, such as the one observed at EkNj-4, were often not aligned along linear features such as river banks and had no limitation on the topographic viewshed (Banks and Snortland 1995). Analysis of the viewshed from the linear arrangement of rings (ie., features 5, 6, 7, 8, 9, 10, 11, and 12), shows that the positioning of these features would allow for unrestricted views in all directions, with the most expansive views toward the south and east (Figures 6.1-4 and 6.1-5), supporting Banks and Snortland's supposition of expansive views from linear camp arrangements. From this vantage the site has a commanding view to the southeast although only two small portions of the lake are visible: one to the east-southeast 2.8 km away on the lake's far shore and the other to the east-southeast, 5.8 km away (Figures 6.1-4 and 6.1-5). This is due to the steeply incised valley in which Little Manitou Lake lies.

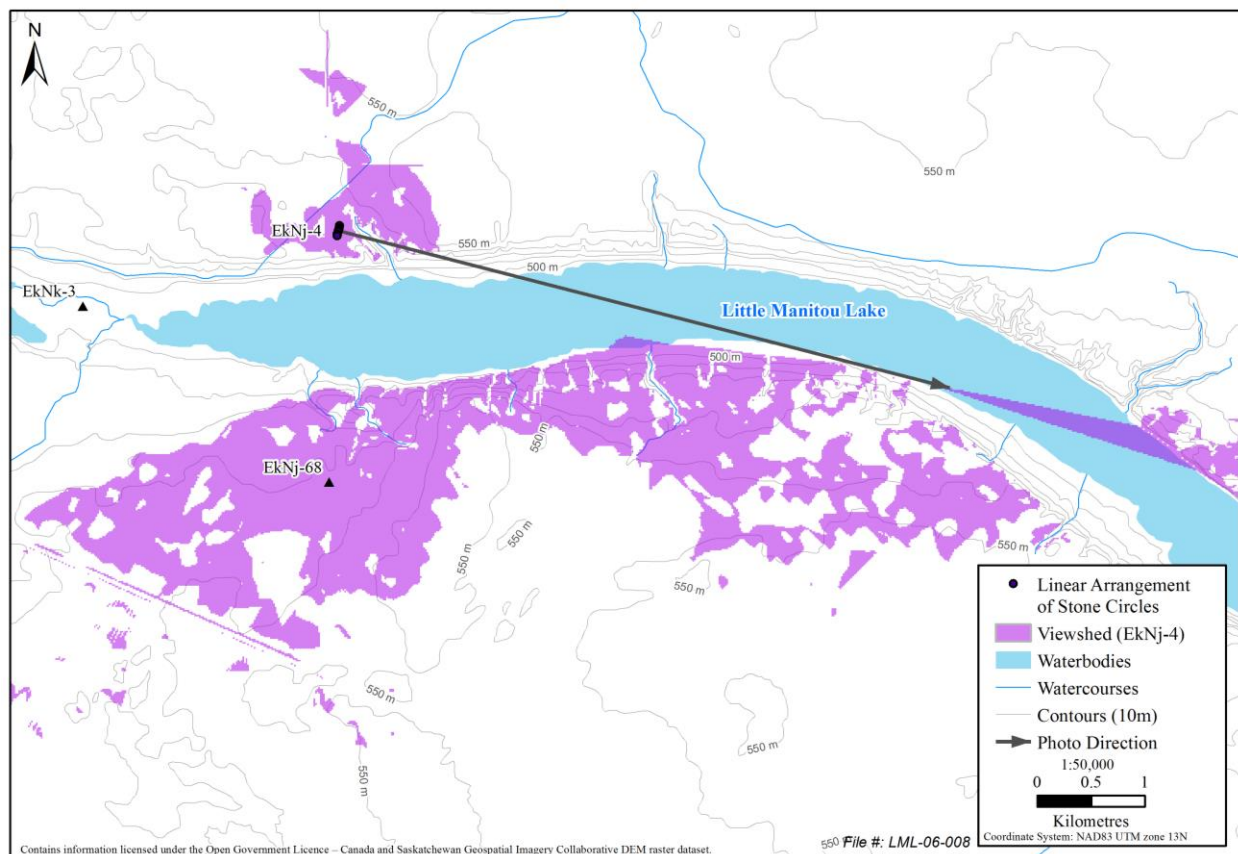


Figure 6.1-4. Viewshed from linear arrangement of stone circle features on the western side of EkNj-4.



Figure 6.1-5. Ground-truthed viewscape from Feature 7 at EkNj-4. View east-southeast illustrating the expansive view from this site (Little Manitou Lake just visible in red oval).

6.1.3 EkNj-68 Spatial Analysis

For EkNj-68, 15 rings were subject to nearest neighbor analysis. The site area is 12,112 m² (1.21 ha). Nearest neighbor results were as follows: $R_o = 17.1746$ m; $R_e = 14.2080$ m; and $R = 1.208795$, indicating a random distribution of features at the site (Figure 6.1.6), which could reflect multiple occupations or may be indicative of large cluster camps which form as irregular arrangements of lodges during periods of aggregation (Banks and Snortland 1995).

As noted in the discussion above for EkNj-4, a common issue with nearest neighbor analysis is the effect that the size of the study area has on the detection and characterization of patterning (Conolly and Lake 2006). There are potentially three isolated/outlying features toward the northern part of EkNj-68. If these features are indeed outliers, the overall site area may have been falsely inflated which in turn influenced the results of the nearest neighbor analysis, providing only a coarse characterization of patterning at this site.

To explore this supposition further, the nearest neighbor analysis was recalculated, this time eliminating the three outlying features in the northern part of the site (Features 1, 2, and 15; see Figure 6.1-8). In this case, the calculated site area was 4,685 m² (0.47 ha; less than half the

site size from the previous calculation) and the nearest neighbor results were as follows: $R_o = 14.1051$ m; $R_e = 9.4922$ m; and $R = 1.485964$, indicating a dispersed/ regular distribution of features at the site (Figure 6.1.6). The results of the z-test indicate that there is a less than 1% likelihood that this dispersed pattern is the result of random chance. Billeck (1983) has suggested that the more regular/uniform the distribution of stone circles, the more likely the features reflect a single occupation, and therefore possibly a group camp. Banks and Snortland (1995) suggest such camps typically consisted of less than 30 habitation structures (often less than 5 dwellings) in an unpatterned arrangement. Further, such a distribution of features may reflect the presence of interrelated peoples, such as extended families (see also Hassrick 1964:173). It is possible that the outlying features (Features 1, 2, and 15) are the result of a different occupation events or represent isolated/specialized structures placed away from the main camp area.

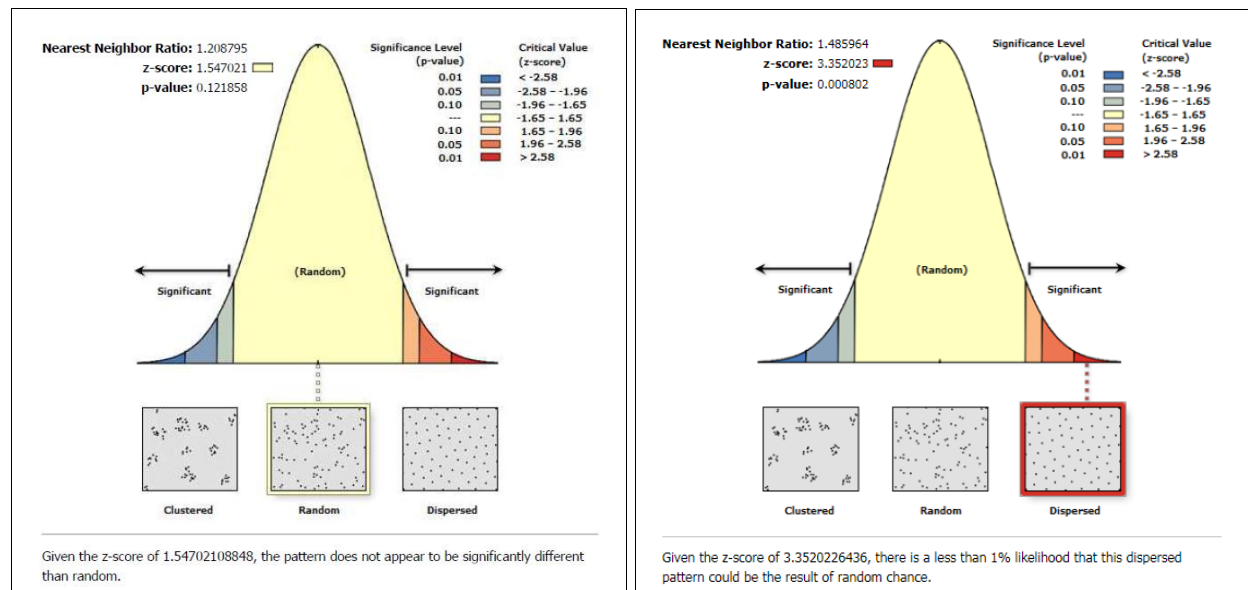


Figure 6.1-6. Results of nearest neighbor analyses for EkNj-68. Left: Site area equal to 12,112 m². Right: Site area equal to 4,685 m² (eliminates Features 1, 2, and 15).

As explored for EkNj-4, a proximity analysis of EkNj-68 utilizing the Buffer tool and the Point Distance (Analysis) tool was employed to aid in reviewing patterning not detected in the nearest neighbor analysis. Although the mean distances between rings generated by the nearest neighbor analyses were 17.17 m and 14.73 m, based on the two nearest neighbor analyses respectively, the median distances between rings fell between 13 and 14 m (14.0 m when all rings were considered or 13.0 m when outlying features were eliminated) (Figure 6.1-7; figures in table rounded to whole numbers). The median distance of 13.0 m was used to create proximity

buffers around ring features illustrated in Figure 6.1-8, producing three clusters (containing 2 to 6 rings per cluster) and two isolated rings.

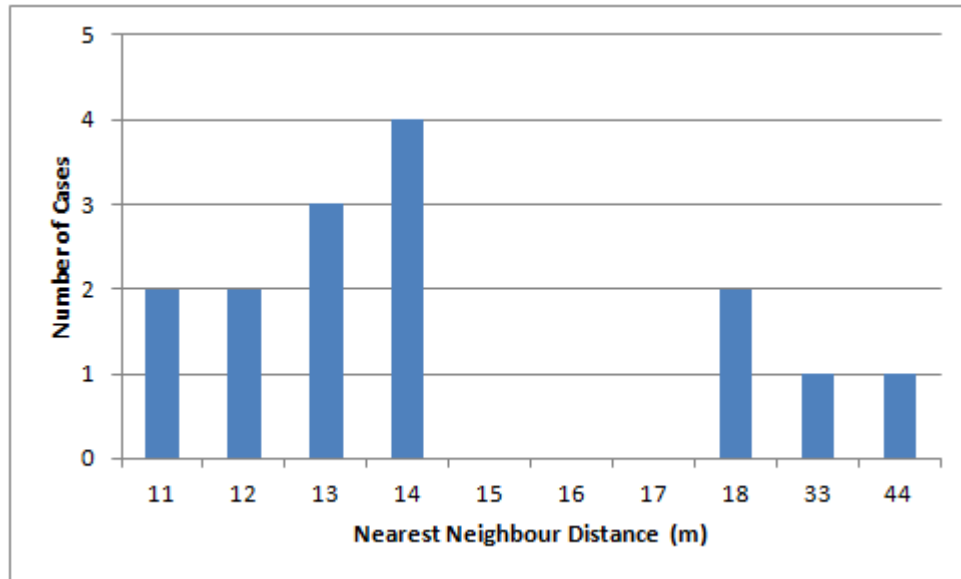


Figure 6.1-7. Distribution of nearest neighbor distances between stone circles at EkNj-68 (note break in consecutive numbering between 18 and 44 m).

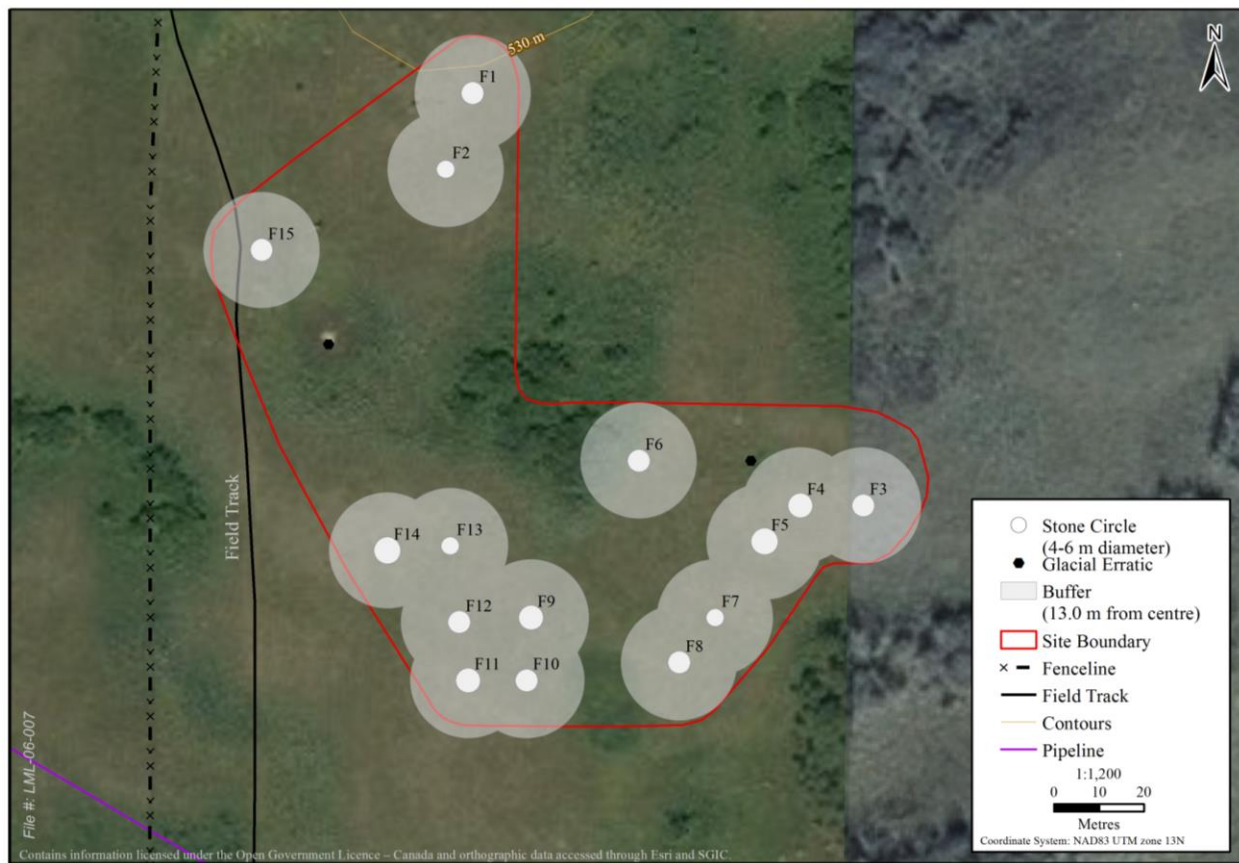


Figure 6.1-8. Site map of features at EkNj-68, showing buffered proximity analysis.

Small clusters containing between two and nine rings are presumed to represent groupings of family units and are likely to be contemporaneous although they could also represent instances of repeated use with features from different use events being placed close to each other (Damkjar 2003; Oetelaar 2003). One linear arrangement of rings was also observed on the east side of the site (features 3, 4, 5, 7, and 8). Such arrangements have been suggested to be a Late Precontact/Protocontact phenomenon possibly related to ceremonial activities (Banks and Snortland 1995; Damkjar 2003). Subsurface testing was not carried out on the features identified in this linear arrangement (ring features 3, 4, 5, 7, and 8) and therefore temporal information remains unknown. Although not included as part of the linear cluster, Feature 11 situated to the west was subject to limited excavations producing a date that correlates to the Protocontact period (see Chapter 5). However, without further subsurface testing at other rings the ages and contemporaneity of features remains unknown, although it is likely that features within clusters are related.

As conducted for EkNj-4, viewshed analysis was carried out for the linear arrangement of features observed at EkNj-68 to determine the extent of visibility from this location. The immediate viewshed from the linear arrangement of rings (*i.e.*, ring features 3, 4, 5, 7, and 8) is quite limited, taking in an area of approximately 200 m immediately around the site (Figure 6.1-9). Beyond and to the northwest of this area, the topography dips away and out of sight into a shallow draw/coulee before rising again into line-of-sight. The most expansive views from the site are toward the north and northwest up the Waterman Marsh valley. Little Manitou Lake does not play a part in the viewshed from this site (the nearest shoreline is approximately 1 km to the north), similar to the viewshed observed for EkNj-4. Today, the site is quite sheltered being surrounded on most sides by stands of aspen and shrubs (Figure 6.1-10).

6.1.4 EkNk-3 Spatial Analysis

Spatial modeling was more challenging for EkNk-3 as good spatial data for features at the site were limited. The site was originally documented in the early 1980s with the resulting site map noting the relative locations of observed features, but geographic coordinates for individual features were not recorded (Kenny 1985). The site was revisited in 2010 and efforts made to relocate previously documented features. However, few stone features illustrated on the original site map could be relocated though several additional stone circles were documented and

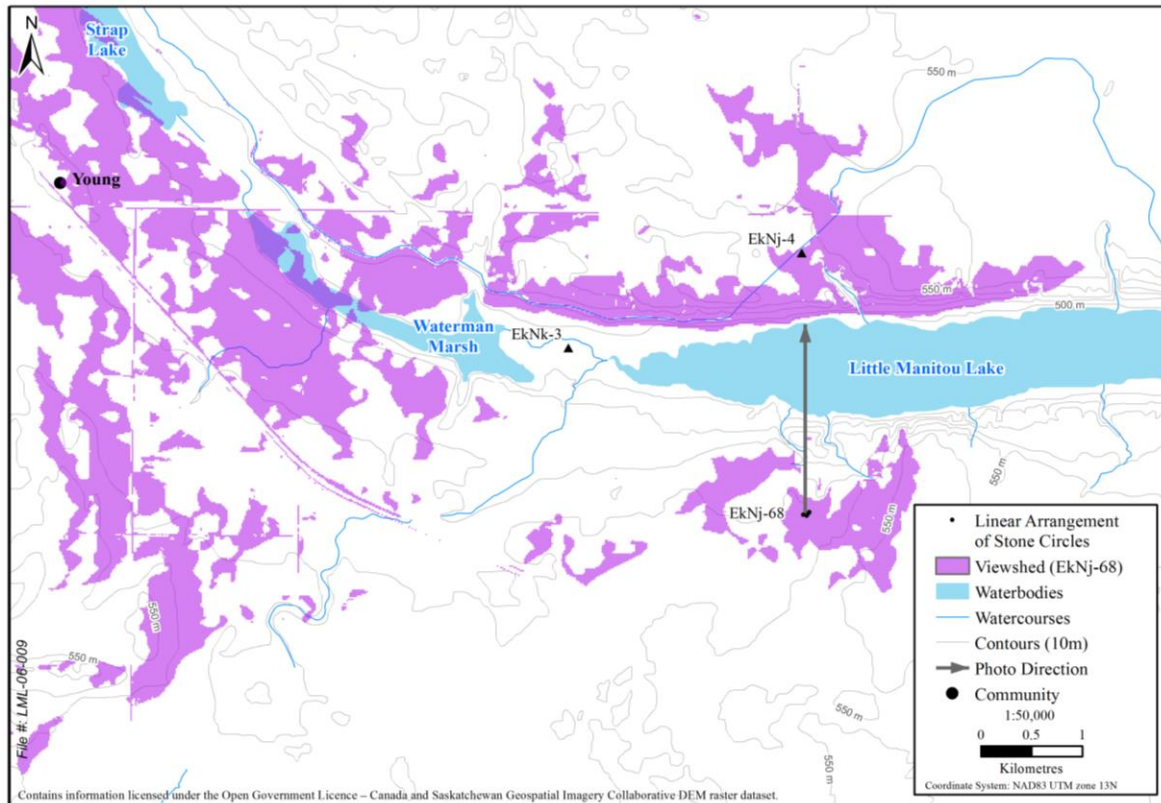


Figure 6.1-9. Viewshed from linear arrangement of stone circle features on the western side of EkNj-68.



Figure 6.1-10. Ground-truthed viewscape from Feature 11 at EkNj-68. View north demonstrating limited view and current vegetation around the site.

added to the site map (Rescan 2011). During the fieldwork carried out for this thesis, attempts were made to locate all documented stone features, but once again efforts were stymied by cattle disturbance and thick grass making feature relocation difficult. Nevertheless, features 2, 3, 4, 5, 6, and 14 were located and GPS coordinates obtained/confirmed. These coordinates and those obtained in 2010 for features 11, 12, 13, 14, and 15 were plotted using ArcGIS 10.3 and the locations for all remaining features (features 1, 7, 8, 9, and 10) were interpolated using site maps and relative positioning to known features. The site boundary was also estimated using a 10 m buffer around the outer most features and topographic features noted on the georeferenced site maps. Coordinates for interpolated feature locations and the revised/digitized site boundary have been included in the SARR update form for this site.

Using the data discussed above, 14 rings were subject to nearest neighbor analysis. The site area is 46,205 m² (4.62 ha). Nearest neighbor results were as follows: $R_o = 43.7420$ m; $R_e = 28.7244$ m; and $R = 1.522815$, indicating a dispersed/regular pattern of features at the site (Figure 6.1.11). The results of the z-test indicate that this dispersed pattern is not the result of random chance. Billeck (1983) has suggested that the more regular/uniform the distribution of stone circles, the more likely the features reflect a single occupation, and therefore possibly a group camp. Banks and Snortland (1995) suggest such camps typically consisted of less than 30 habitation structures (often less than 5 dwellings) in an unpatterned arrangement. Further, such a

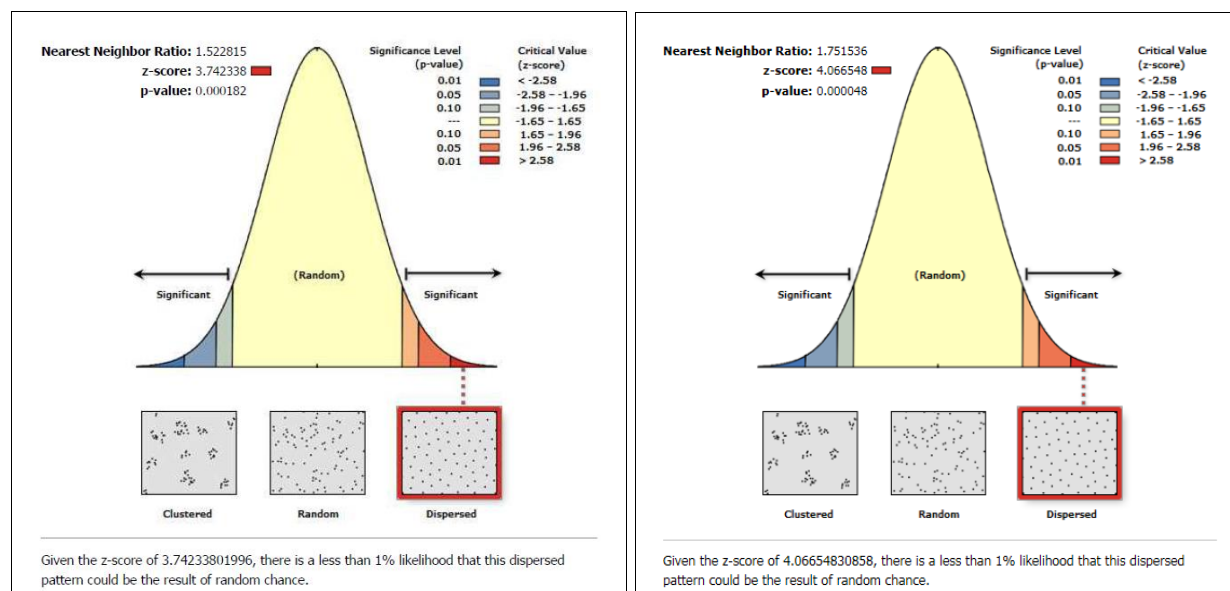


Figure 6.1-11. Results of nearest neighbor analyses for EkNk-3. Left: Site area equal to 46,205 m². Right: Site area equal to 3,429 m² (eliminates Features 1, 10, 12, 13, 14, and 15).

distribution of features may reflect the presence of interrelated peoples, such as extended families (see also Hassrick 1964:173).

As noted in the discussion above for EkNj-4 and EkNj-68, a common issue with nearest neighbor analysis is the effect that the size of the study area has on the detection and characterization of patterning (Conolly and Lake 2006). There are potentially six isolated features around the outer edges of the site. If these features are indeed outliers, the overall site area may have been falsely inflated which in turn influenced the results of the nearest neighbor analysis, providing only a coarse characterization of patterning at this site.

To explore this supposition further, the nearest neighbor analysis was recalculated, this time eliminating the six outlying features around the outer edges of the site, all being over 40 m away from neighboring features (Features 1, 10, 12, 13, 14, and 15; see Figure 6.1-13). In this case, the calculated site area was 3,429 m² (0.34 ha) and the nearest neighbor results were as follows: $R_o = 18.1334$ m; $R_e = 10.3528$ m; and $R = 1.751536$, once again indicating a dispersed/regular pattern of features at the site (Figure 6.1.11). Although similar patterning is suggested from the recalculated nearest neighbor analysis, the results likely reflected the relatively regularly spaced features at the centre of the site. Whether or not the six outlying features relate to those located at the centre of the site remains unknown and would require additional subsurface testing to determine contemporaneity.

As explored for EkNj-4 and EkNj-68, a proximity analysis, utilizing the Buffer tool and the Point Distance (Analysis) tool, was employed to aid in reviewing possible patterning not detected in the nearest neighbor analysis. Although the mean distances between rings generated by the nearest neighbor analyses were 43.74 m or 18.13 m, based on the two nearest neighbor analyses, respectively. The median distances between rings fell between 17.5 and 28 m (27.4 m when all rings were considered or 17.5 m when outlying features were eliminated) (Figure 6.1-12; figures in table rounded to whole numbers). The median distance of 17.5 m was used to create proximity buffers around ring features illustrated in Figure 6.1-13, producing one cluster in the centre of the site (containing 8 rings) and six isolated rings.

The cluster at the centre of the site is roughly linear in arrangement (particularly the northwestern end comprised of features 2, 3, 4, 5, and 6) which has been suggested to be a Late Precontact/Protocontact phenomenon (Banks and Snortland 1995; Damkjar 2003). Limited subsurface testing was carried out at ring feature 2 at the northwestern end of this linear

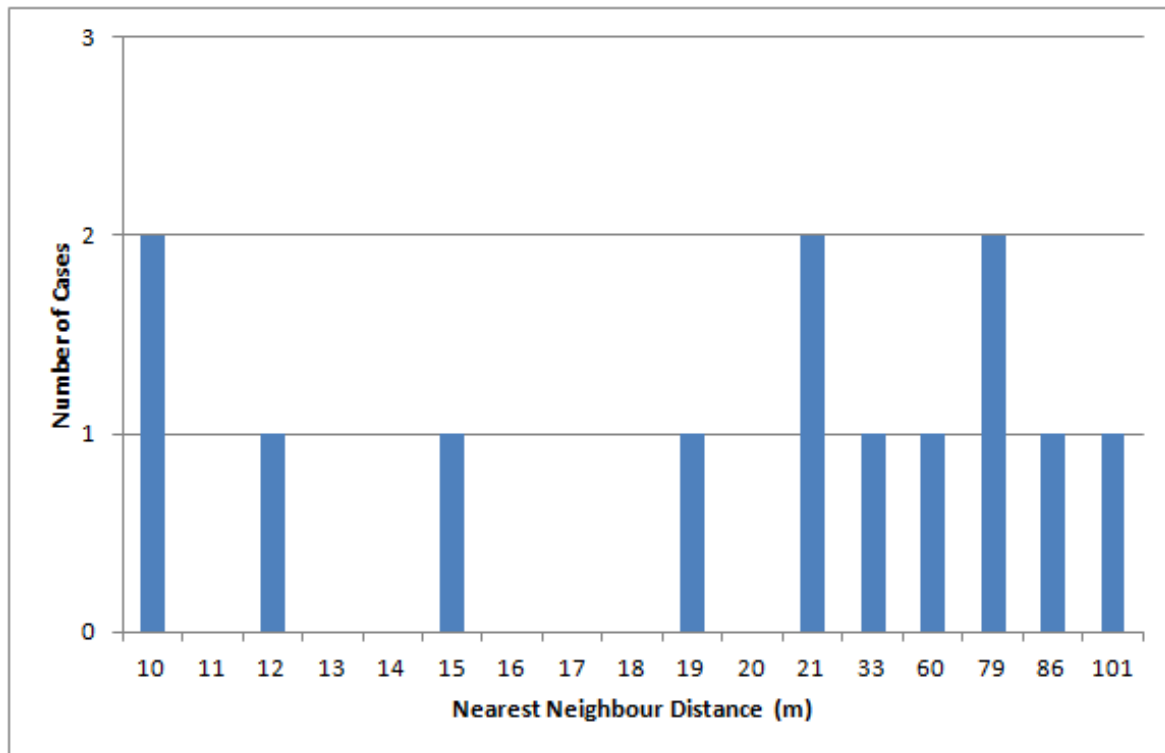


Figure 6.1-12. Distribution of nearest neighbor distances between stone circles at EkNk-3 (note break in consecutive numbering between 21 and 101 m).

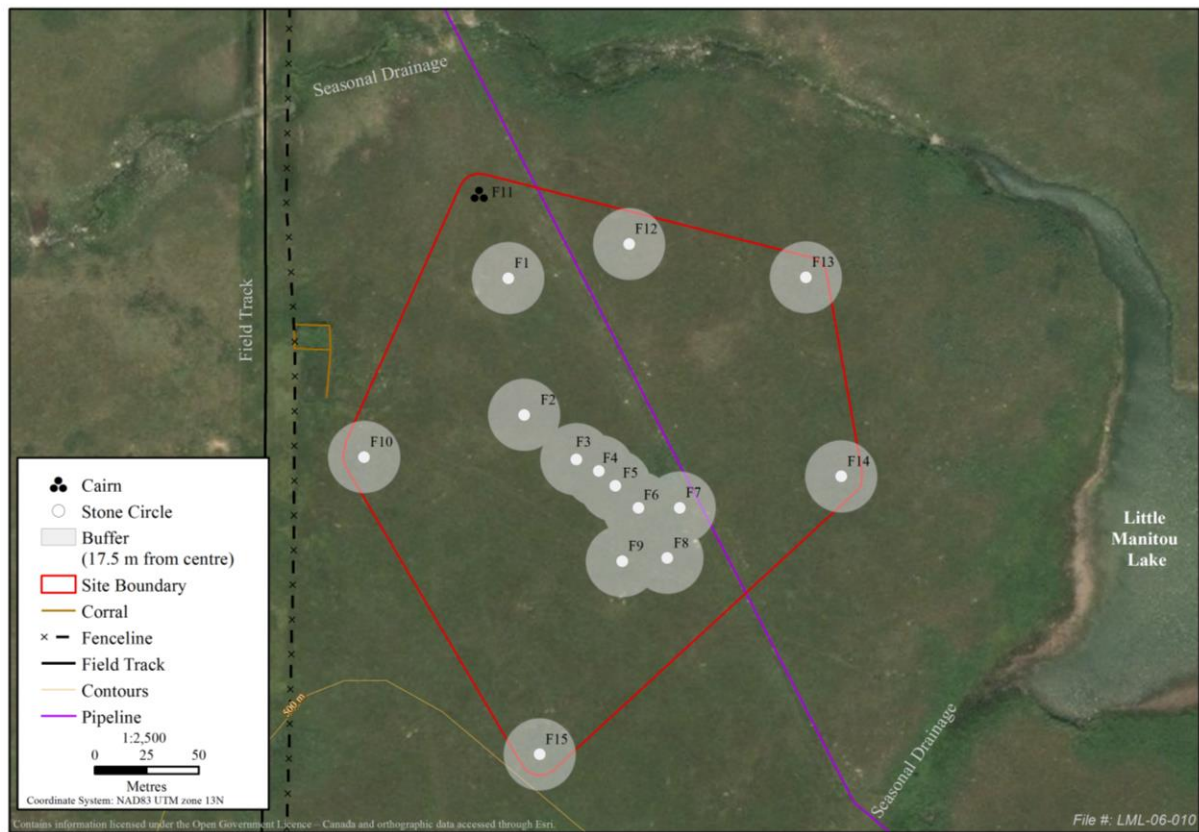


Figure 6.1-13. Site map of features at EkNk-3, showing buffered proximity analysis.

arrangement producing material dated to the terminal Late Precontact period (see Chapter 5). Without further subsurface testing at other rings at this site, the temporal framework and contemporaneity of features remains unknown, although it is possible that features within this cluster are related.

As conducted for EkNj-4 and EkNj-68, viewshed analysis was carried out for the linear arrangement of features observed at EkNk-3 to determine the extent of visibility from this location. The local viewshed from the linear arrangement of rings (consisting of ring features 2, 3, 4, 5, and 6) is largely limited to the Little Manitou Lake valley to the east of the site (Figure 6.1-14). The sites position at the valley bottom and the steep valley walls predicate limited visibility of the terraces above the lake to the north and south. Waterman Marsh, the fresh waterbody to the west, is entirely out of the field-of-view from this site due to a slight rise in topography to the west of the site. Figures 6.1-14 and 6.1-15 illustrates the present viewsapes from this site.

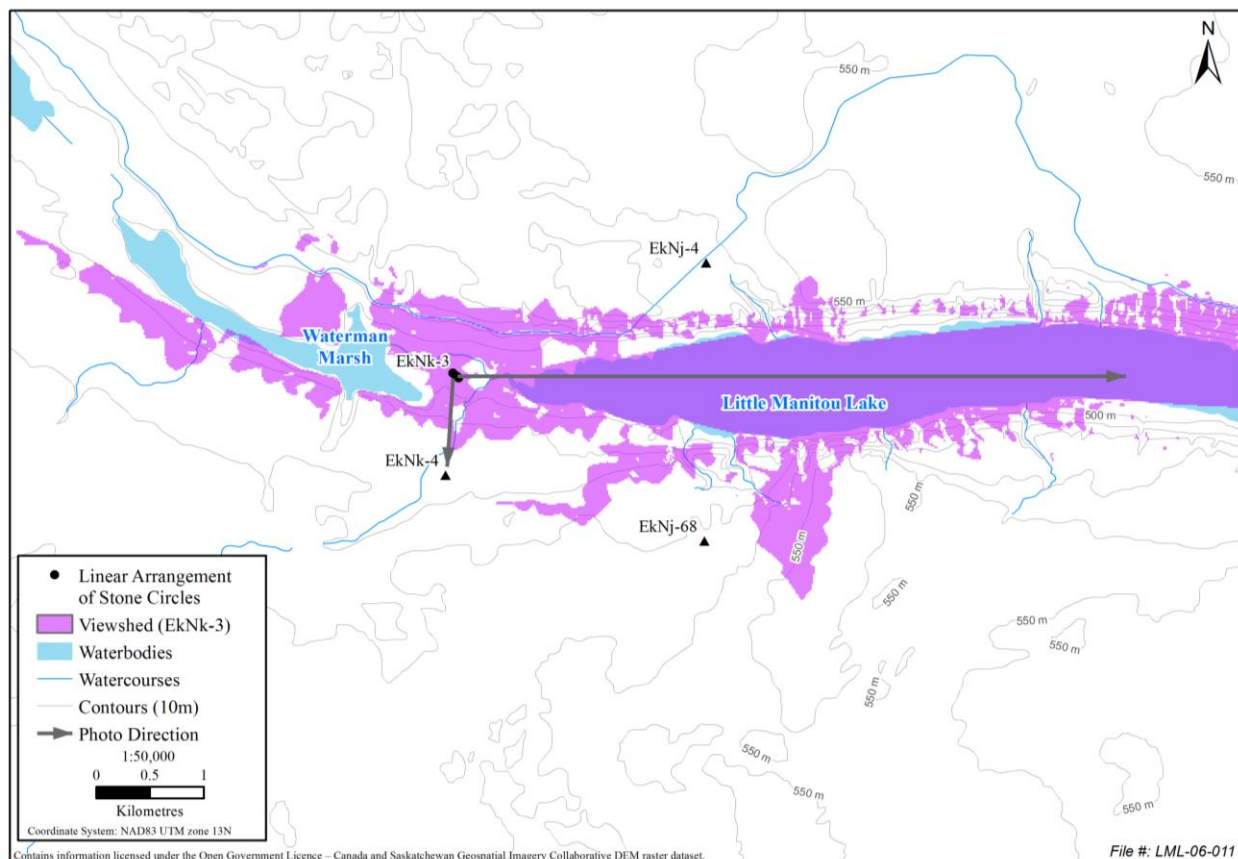


Figure 6.1-14. Viewshed from linear arrangement of stone circle features at EkNk-3.



Credit: K. Jollymore 2015

Figure 6.1-15. Ground-truthed viewscape from Feature 2 at EkNk-3. View east down the Little Manitou Lake valley.



Credit: K. Jollymore 2015

Figure 6.1-16. Ground-truthed viewscape from Feature 2 at EkNk-3, view south. White arrow indicates location of ceremonial site EkNk-4 (discussed in Section 6.2) - located beyond the stand of trees and outside of the viewshed for this site.

6.1.5 Summary

Initial nearest neighbor analyses carried out for EkNj-4 and EkNj-68 returned results suggesting that the distribution of ring features at these sites is random while the results for EkNk-3 suggest that the distribution of ring features is dispersed/regular. However, as noted by Conolly and Lake (2006), a common issue observed with nearest neighbor analysis is the effect that site area has on the detection and characterization of patterning. Although nearest neighbor analysis has been carried out for other stone circles sites (e.g., Damkjar 2003), given the problems that can arise from inflated site area due to the presence of outlying features, nearest neighbor analyses were recalculated for all three sites, eliminating outlying features. Recalculated results for EkNj-4 and EkNk-3 did not change, suggesting that the results of nearest neighbor analysis accurately reflect feature distribution at these sites. However, recalculated results for EkNj-68 suggest that the core area of the site reflects dispersed/regular distribution of features, perhaps indicative of an occupation of interrelated people.

Once outliers were excluded from datasets, the median distance between rings was used to create proximity buffers around rings, to illustrate patterning not detected by nearest neighbor analysis. All sites demonstrated areas of linear clustering which has been suggested to correlate with Late Precontact/Protocontact camp arrangements as well as an association with ceremonial activities. In addition, all sites contained small clusters of rings (typically including two to nine rings) which have been suggested to represent groupings of family units and are likely to be contemporaneous.

Viewshed analyses were carried out for these sites to evaluate the extent of line-of-sight and landscape features which are visible. Although Little Manitou Lake is a prominent landscape feature, it did not play a significant role in the viewsheds for EkNj-4 or EkNj-68. Not surprisingly, given the site's position on the landscape, the lake did play a significant role in the viewshed for EkNk-3.

6.2 Ceremonial Landscape

To evaluate the ceremonial landscape at the western end of Little Manitou Lake, viewshed analysis was carried out to better understand how these special places relate to each

other and the landscape overall. Irwin (1994:56) has suggested that a primary principle of Native American visionary experience on the Great Plains is the power of direction; directionality being a "dynamic and mythically charged form of cosmological orientation". He goes on to state that

directions, in general, include not only the explicit, literal direction (as north or south) but also implicit realms of significance that are structured through visionary experience, ritual movement, the use of objects, and narrative traditions. Each direction enfolds a variable complex of qualities and powers emphasizing color, particular beings (plants and animals), and geographical landmarks....one of the most fundamental expressions of spatial order comes from the association of power with directionality...[which] is an essential feature of almost all visionary experiences....[and one which is] subjective [to the] experience of the individual or the collective activities of the people as a whole [Irwin 1994:56-59].

Directionality and inter-visibility were therefore expected to play a role in the placement of ceremonial sites within the landscape. This section outlines the methods used to evaluate the ceremonial landscape and the results of the spatial analysis.

6.2.1 Methods

The methods used to evaluate visibility from ceremonial sites followed similar procedures to those outlined in Section 6.1.1 for domestic sites, with some additions. For most sites considered in this analysis, the location of the site datum was used to model the viewsheds. However, for EkNj-51, the location of the ceremonial feature (Feature 39 - a vision quest depression) was used since the feature is an outlier, situated 240 m upslope of the site datum and other features at the site. This was done to accurately reflect the field-of-view from the ceremonial feature at this site and the lines-of-sight between other ceremonial sites.

To produce viewsheds for ceremonial sites, ground elevation values were extracted from the SGIC DEM raster dataset for ceremonial feature locations using the Extract Values to Points (Spatial Analyst) and Features to 3D By Attribute (3D Analyst) tools in ArcGIS 10.3. Once raster values were obtained, site locations were subject to analysis using the Viewshed (Spatial Analyst) tool in ArcGIS 10.3 to produce a viewshed/field-of-view output for each site. The results for each individual viewshed were then combined using the Raster Calculator in ArcGIS 10.3 to create a cumulative viewshed for all eight ceremonial sites to evaluate areas of visual prominence and inter-visibility within the cultural landscape (Zomora 2007). Viewscapes from these sites were also ground-truthed during which photographs of the present fields-of-view were taken at cardinal and ordinal directions to verify modeled results.

Distance between sites/objects was also considered to be a factor in inter-visibility. The World Meteorological Organization suggests an object must occupy at least 0.5° of the total view relative to a viewer to be seen, and stand out from its surroundings (WMO 2008). This means that at 0.5 km an object must be 4.3 m in height or width to be discernible. Distance between ceremonial sites were therefore also calculated.

6.2.2 Ceremonial Site Viewsheds

Eight ceremonial sites documented around the western end of Little Manitou Lake were considered in this spatial analysis (Table 6.2-1). These features include medicine wheels, stone alignments, vision quest features, and a prominent glacial erratic. The results of the analysis revealed that all sites were inter-visible with at least two other ceremonial sites (Figure 6.2-1, Table 6.2-1). Distances between sites ranged from 0.12 km to 6.9 km (Table 6.2-2).

Table 6.2-1. Inter-visibility of ceremonial sites at Little Manitou Lake.

Site	Ceremonial Features	Number of Sites Visible	Sites Visible
EkNj-5*	Medicine wheels	4	EkNj-15, EkNj-21, EkNj-51(F39), EkNk-4
EkNj-15*	Stone alignment	4	EkNj-5, EkNj-33, EkNj-51 (F39), EkNk-4
EkNj-21*	Ceremonial circles	3	EkNj-5, EkNj-27, EkNj-51 (F39)
EkNj-22*	Medicine wheel	2	EkNj-33, EkNk-4
EkNj-27*	Stone alignment	2	EkNj-21, EkNk-4
EkNj-33*	Medicine wheel	4	EkNj-15, EkNj-22, EkNj-51, EkNk-4
EkNj-51 [§]	Vision quest (Feature 39)	5	EkNj-5, EkNj-15, EkNj-21, EkNj-33, EkNk-4
EkNk-4 [†]	Vision quest/Glacial erratic	6	EkNj-5, EkNj-15, EkNj-22, EkNj-27, EkNj-33, EkNj-51

*Rescan (2011); [§]Rescan (2012b); [†]Cyr-Steenkamp et al. (2010).

Table 6.2-2. Distances between ceremonial sites at Little Manitou Lake (values in kilometres).

	EkNj-5	EkNj-15	EkNj-21	EkNj-22	EkNj-27	EkNj-33	EkNj-51	EkNk-4
EkNj-5								
EkNj-15	1.99							
EkNj-21	2.46	1.08						
EkNj-22	2.1	3.16	4.06					
EkNj-27	3.93	3.83	2.89	6.02				
EkNj-33	2.22	3.22	4.17	0.13	6.15			
EkNj-51	1.48	2.48	3.38	0.69	5.36	0.8		
EkNk-4	3.39	3.27	4.45	1.9	6.92	1.85	2.07	

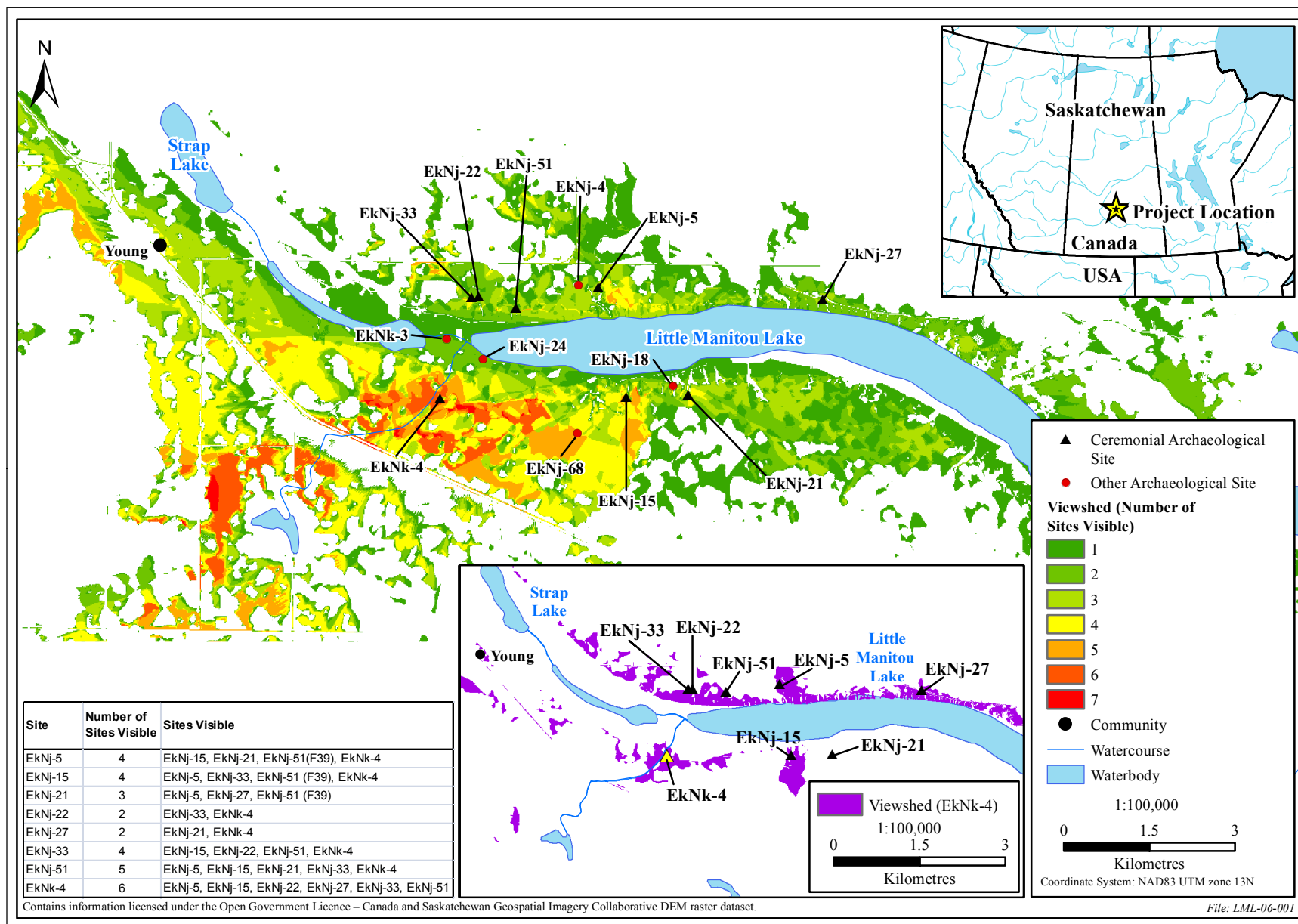


Figure 6.2-1. Results of cumulative viewshed analysis for ceremonial sites at the western end of Little Manitou Lake.

EkNj-5 is located on the northern side of the lake. It contains 10 cairns, 26 stone circles, two stone alignments and two ceremonial features: a medicine wheel with six spokes (Feature 4; medicine wheel subgroup 5 [Brumley 1988]) and a medicine wheel which consists of a central cairn surrounded by a stone circle (Feature 23; medicine wheel subgroup 1 [Brumley 1988]) (Rescan 2011). The viewshed results for this site indicate that 1,383 ha can be seen from this sites and four other ceremonial sites are within line-of-site: three sites on the south side of the lake (EkNj-15, EkNj-21, and EkNk-4) and the ceremonial feature at EkNj-51 (F39) situated to the west (see Table 6.2-2 for distances between sites). Little Manitou Lake is not visible from the features at this site. Because the two ceremonial features at this site are 239 m apart at opposite ends of the site, separate viewsheds results were produced to evaluate differences. The field-of-view from feature 23 was somewhat broader but did not change the overall viewshed results.

EkNj-15 is located on the southern side of the lake on the top of a narrow ridge. It consists of a stone alignment in a V shape; the point of the V points roughly east (Rescan 2011). This feature is unlike any others observed in this cultural landscape; it is reminiscent of the large flocks of geese which use the lake during spring and fall migration, often flying east-west along the length of the lake. The viewshed results for this site indicate that 2,580 ha are within the field-of-view and four other ceremonial sites are within line-of-site: three on the north side of the lake (EkNj-5, EkNj-33, and EkNj-51) and the glacial erratic and accompanying site (EkNk-4) (see Table 6.2-2 for distances between sites). Two of these sites (EkNj-51, EkNk-4) contain vision quest features and two (EkNj-5, EkNj-33) contain ceremonial circles/medicine wheels. The viewshed results also illustrated that the western end of the lake is visible.

EkNj-21 is located on the south side of the lake in a slight dip in topography. The site contains three stone circles and two ceremonial circles both of which enclose stone cairns (four cairns in F1 and three cairns in F2) (Ceremonial Circle Subclass C [Brace 2005]) (Rescan 2011). The ceremonial circles at this site are unlike others documented in this cultural landscape as both features contain multiple linear cairns. The results of the viewshed analysis for this site illustrated a narrow field-of-view from this site, with only 1,149 ha visible, the second smallest field-of-view of the ceremonial sites modeled. Inter-site visibility from this location was limited to only three other ceremonial sites, all on the north side of the lake: EkNj-5, EkNj-27, and EkNj-51(F39) (a medicine wheel site, a stone alignment site, and a vision quest site) (see Table 6.2-2 for distances between sites). This could be indicative of its chronological sequence of

construction compared with other ceremonial sites evaluated, although the chronological sequence of construction would be difficult to determine.

EkNj-22 is located on a flat area on the north side of the lake. The site contains a medicine wheel (subgroup 7 [Brumley 1988]) consisting of a circle (12 m in diameter) enclosing a stone cairn with two spokes which transect the circle on the northern and eastern sides (Rescan 2011). The site also contains two stone circles and a linear stone alignment running between the two stone circles. The viewshed results for this site indicate a small field-of-view with only 1,226 ha visible, extending primarily north and south from the site, and did not include line-of-sight to Little Manitou Lake. Only two other ceremonial sites were visible from this location: EkNj-33 (a ceremonial circle site) and the vision quest/glacial erratic site EkNk-4 (see Table 6.2-2 for distances between sites). The limited view from this site was unexpected since it is on a terrace above the lake, is at the head of a draw leading down to Little Manitou Lake which was not anticipated to impede the view, and is only 125 m east of ceremonial site EkNj-33 which has a much more expansive field-of-view (nearly double that of EkNj-22). Unfortunately, ground-truthing of the modeled viewshed could not be carried out at this site as access was not granted by the land-owner. Like the limited viewshed observed at EkNj-21, this could be indicative of the sites chronological sequence of construction compared with other ceremonial sites evaluated.

EkNj-27 is located on the north side of the lake and is the most easterly ceremonial site considered. The site contains a cairn, two stone alignments, and an oval stone feature (Rescan 2011). The oval feature (F2) is oriented north-south and one of the stone alignments (F3) extends 2.2 m to the southwest (at a bearing of 220°) from its southwest corner. The other stone alignment (1.5 m in length at a bearing of 240°; F4) parallels the first but does not intersect the oval. The cairn (F1) is linear and parallels the alignments on the west side of the oval and north side of the alignments (at a bearing of 260°). To determine if the stone alignments and linear cairn point to specific landscape or archaeological features, directionality of the alignments was modeled. Linear cairn F1 intersects with EkNj-24, a site containing a stone oval near the western end of Little Manitou Lake (Figure 6.2-1). Alignment F3 does not intersect with any known archaeological site or prominent landscape feature while alignment F4 intersects with a cairn situated on a ridge top on the southern side of the lake at EkNj-18 (Figure 6.2-1). While the results of the stone feature directionality do show some intersection with other ceremonial sites, it is unclear if these results were intended by the original builder of this site. The viewshed

results for this site indicate a fairly expansive field-of-view with 2,799 ha visible (the second largest of the ceremonial sites modeled) which includes much of the southern side of the lake and its western end. Despite this, only two ceremonial sites are within line-of-sight from this location: EkNj-21 and EkNk-4 (see Table 6.2-2 for distances between sites). However, the fact that EkNj-27 is the most easterly site considered likely plays a factor in limited ceremonial site inter-visibility given the overall distance (between 2.89 and 6.15 km) from other ceremonial sites (Table 6.2-2).

EkNj-33 is located on a small knoll on the northern side of the lake. The site contains a large medicine wheel which consists of a central cairn enclosed by a stone circle (subgroup 1 [Brumley 1988]) (Rescan 2011). No other features have been documented at this site. The field-of-view from this site indicates that 2,258 ha can be seen from this site with the majority of the viewshed consisting of a portion of the southern side of the lake and then extending up the southern side of the Waterman Marsh valley. From this vantage neither Little Manitou Lake nor Waterman Marsh are visible. Four other ceremonial sites are within line-of-sight: EkNj-15 and EkNk-4 on the southern side of the lake and EkNj-22 and EkNj-51 on the northern side of the lake, to the east (see Table 6.2-2 for distances between sites).

EkNj-51 is located on a terrace on the northern side of the lake. The site contains 47 stone circles and a circular vision quest depression. The depression (Feature 39) is 30 cm deep and is both lined with and surrounded by stones. The depression is some distance from the other features at this site; the nearest stone circle is 45 m downslope. The viewshed from this feature takes in a small area immediately to the north of the site as well as hilltops to the east and west. However, the most extensive view from this feature (with 3,567 ha visible, the largest of all ceremonial sites modeled) is around the southern side of the lake, covering the terrace along much of the western end of the lake and extending up the Waterman Marsh valley. Yet neither Little Manitou Lake nor Waterman Marsh are visible. Five other ceremonial sites are within line-of-sight: EkNj-5, EkNj-21, and EkNj-33 on the northern side of the lake and EkNj-15 and EkNk-4 on the southern side of the lake (see Table 6.2-2 for distances between sites).

Perhaps most interesting are the viewshed results for EkNk-4. Despite this site having the smallest fields-of-view compared with all other ceremonial sites in this landscape (636 ha), it is visible from most ceremonial sites (Figure 6.2-1 - inset, Table 6.2-1). Six of the seven other ceremonial sites had inter-visibility with this location (the exception being EkNj-21) (Figure 6.2-

1; see Table 6.2-2 for distances between sites). The site is also the largest in the region, containing 147 features and covering an area of approximately 1.68 km² (2.1 km x 0.8 km). It contains 111 stone circles (the largest cluster of stone circles in the study area), 32 cairns, and three pit features (two of which are circular stone-lined features surrounded by stones, very similar to the vision quest feature at EkNj-51). The site also contains a prominent glacial erratic which stands 4 m tall and is 10.4 m by 6.7 m wide (Figure 6.2-2; Cyr-Steenkamp et al. 2010). This erratic has been reported to be the largest glacial erratic in the southern half of the province, is known as the *Grandfather Rock* by local First Nations, and is thought to be of ceremonial significance (Cyr-Steenkamp et al. 2010; McDougall 2000). The viewshed results suggest that the location played a prominent role as a focal point within the precontact ceremonial landscape.



Figure 6.2-2. The glacial erratic at EkNk-4, looking northeast. Recent wet years have filled the basin around the erratic with a seasonal pond, hunters have installed a blind on its top, and past graffiti is still evident.

To evaluate if there would be any difference between the viewshed from the ground surface at this site, compared with an individual standing on the glacial erratic, viewshed

modeling for this feature was also carried out for an elevation 5.5 m above the raster elevation value for the site (original raster value 518 m + 4 m erratic height + 1.5 for average human height = 523.5 m). Interestingly, negligible changes in viewshed results were observed.

Although distance between sites undoubtedly played a role in site inter-visibility for all ceremonial sites within this landscape, particularly for the large glacial erratic at EkNk-4, Irwin (1994:59) notes that it is an individual's relationship with geographical landmarks which provides a sense of orientation and that the "sense of direction is not an absolute...[but] rather, the lived world of ritual movement, multidimensional visionary experience, and personal perception [that gives] structure and meaning through certain relatively stable features of both the natural and visionary landscape". That considered, while the glacial erratic at EkNk-4 may not have been explicitly visible from other ceremonial sites within this landscape (all other sites were more than 1.8 km away and therefore likely not visible with the naked eye - see Table 6.2-2 and Section 6.2.1), an individual's sense of place may have influenced their awareness of where these important places were situated within this landscape.

The only ceremonial site within this landscape which is not visible from EkNk-4 is EkNj-21, situated on the south side of the lake in a slight hollow (Figure 6.2-3). The lack of inter-visibility between EkNj-21 and EkNk-4 versus the prominence of the glacial erratic site with other ceremonial sites may speak to a difference in site function at EkNj-21 and/or perhaps a different occupation phase during a period when the glacial erratic may not have had cultural significance. While the other medicine wheels/ceremonial circles documented within this cultural landscape consist of cairns enclosed by circles (referred to as medicine wheel subgroup 1 by Brumley [1988]), the features at EkNj-21 differ in that they consist of three to four linear cairns enclosed by stone circles. Although not conclusive, the difference in style may suggest an alternate purpose for this site which in turn may explain its position in the landscape and its limited visibility between other ceremonial sites (described previously above; Table 6.2-1).

Prominence of site viewshed and inter-site visibility, such as that demonstrated at EkNk-4, has been observed in other studies where spatial analysis has helped in the interpretation of archaeological landscapes (e.g., Lock and Harris 1996). While current understandings of the meaning of precontact features is limited, use of spatial analysis helps shed light on past landscape use providing a phenomenological perspective of viewscapes and insights pertaining to visual symbolism (Owac 2006; Tilley 1996). Large stones like the glacial erratic at



Figure 6.2-3. Ground-truthed view from EkNj-21, looking northwest. Note rise of hill to the left which limits the view toward EkNk-4 and most other ceremonial sites. The location of site EkNj-5 is noted by the white arrow, one of two ceremonial sites visible from this location.

EkNk-4 can hold special significance for aboriginal people and are often associated with archaeological sites (Hanna and Gibson 1993; Tilley 1996; see Chapter 7 for further discussion).

Interestingly, Little Manitou Lake does not play an important role in the viewsheds of many of the ceremonial sites in this landscape. Although ceremonial sites in the area have been hypothesized to relate to the saline/healing nature of Little Manitou Lake (Cyr-Steenkamp et al. 2010; Watrous History Book Society 1983), the lake clearly did not play an important part in the visual landscape of these ceremonial places.

Unfortunately, spatial analysis in this landscape is somewhat impeded by the paucity of securely dated sites and the inability to filter out sites which are not contemporaneous, thereby limiting the opportunity to model only those sites which have a common temporal/cultural framework. Determining whether ceremonial sites are contemporaneous would help to better understand the cultural landscape. However, ceremonial sites are difficult to date, as are stone circle sites which make up the majority of site types within this region; the likelihood of dating these ceremonial features is slim. Instead, the researcher is left to consider all of the ceremonial

sites as a whole. While this provides some insight into a comprehensive view of landscape use, it limits the ability to discuss temporal ceremonial landscape use.

Prior to conducting this research, physical separation between domestic and ceremonial sites was anticipated. However, without a temporal framework for many of these sites, both ceremonial and domestic, this becomes difficult to determine. While the fields-of-view of some ceremonial sites include more domestic sites than others (Table 6.2-3), no clear division or pattern is evident. Separation between domestic and ceremonial sites is further hampered by some ceremonial sites containing domestic architecture (e.g., stone circles). In such cases, it is difficult to determine if the ceremonial features at these locations are contemporaneous with nearby domestic features. In some instances, such as the features present at ceremonial site EkNj-22, division between the ceremonial feature (medicine wheel - measuring 7 m in diameter) and some of the domestic-style architecture (stone circles - each measuring 4 m in diameter) is present, delineated by a linear stone alignment which runs between the stone circles. However, without further work at this site to verify if the stone circles do indeed relate to domestic activities, this question will remain unanswered.

Table 6.2-3. Inter-visibility of ceremonial and domestic sites at Little Manitou Lake.

Ceremonial Site	Number of Domestic Sites Visible
EkNj-5	10
EkNj-15	21
EkNj-21	18
EkNj-22	3
EkNj-27	11
EkNj-33	7
EkNj-51	13
EkNk-4	13

6.3 Chapter Summary

Nearest neighbor and proximity analyses carried out for EkNj-4, EkNj-68, and EkNk-3 provided insight about the spatial arrangement of features at these sites. Initial nearest neighbor analyses for EkNj-4 and EkNj-68 suggested a random distribution of features while EkNk-3 showed a dispersed/regular distribution. However, some caution is warranted in accepting these results as they all contain outlying features which may falsely inflate the site area considered and influence the accuracy of the results. Therefore, nearest neighbor analyses were recalculated,

eliminating outlying features. Results for EkNj-4 and EkNk-3 did not change, while the results for EkNj-68 suggest that the core area of the site reflects a dispersed/regular distribution of features.

Proximity analyses were also employed to illustrate areas of potential patterning not detected by nearest neighbor analyses. All sites demonstrated some areas of linear clustering which has been suggested to correlate with Late Precontact/Protocontact camp arrangements as well as with ceremonial activities. In addition, all sites contained small clusters of rings which have been suggested to represent groupings of family units and are likely to be contemporaneous.

Viewshed analysis was conducted for EkNj-4, EkNj-68, and EkNk-3. Results illustrate that visibility to Little Manitou Lake did not play a significant role in site placement for EkNj-4 and EkNj-68. However, given the location of EkNk-3 at the western end of the lake, Little Manitou Lake was highly visible from this site.

Results of the viewshed analyses conducted for the ceremonial sites in this cultural landscape suggest that site inter-visibility between ceremonial sites may have played a critical role in site placement. In particular, the visual dominance of the most prominent landscape feature in the area, the glacial erratic at EkNk-4, may have played a key role in determining where other ceremonial sites were placed on the prehistoric landscape.

Chapter 7

Interpretation and Discussion

This chapter provides interpretations and discussion of the primary research objective, improving our understanding of interactions between past human populations and the environment of the Little Manitou Lake area. The results presented in Chapters 5 and 6, as well as information outlined in Chapters 2 and 3, form the basis for this discussion.

7.1 Archaeological Material

As described in Chapters 4 and 5, the research design for this project targeted very small areas at each investigated site which were subject to subsurface testing (less than 2 m² at each site). As such, few cultural materials, either artifactual or faunal, were recovered. Consequently little can be said about distributional patterns at these sites. The paucity of bone also makes it impossible to draw conclusions about diet and resource allocation other than to say that bison was a resource utilized by the people at these sites. Paleobotanicals recovered from the hearths reveal something about locally occurring plants which may have been used as resources, and help to characterize the prevailing environment at the time the sites were occupied. Typically, low densities of cultural material recovered from archaeological sites have been interpreted as indicating a very short period of occupation. However, given the limited excavation, one cannot reasonably come to that conclusion in the current case. Nevertheless, the materials and features identified at these sites do shed light on activities which took place.

7.1.1 Lithic Materials

No diagnostic tools were recovered from any of the sites investigated but expedient flaked tools were recovered along with small hammerstones (peckingstones) and lithic debitage produced from locally available lithic resources. Lithic reduction activities were generally limited to the removal of small flakes typically less than 1 cm in maximum length. Debitage with cortex was recovered from EkNj-68 and EkNk-4 but it makes up a small portion of these

assemblages. Overall, lithic materials recovered from these sites suggest limited stone tool use and maintenance.

None of the debitage recovered was heat-altered. Few artifacts were found in the hearth depressions but instead were found on the peripheries. It seems likely that these artifacts represent deposition as a result of what Binford (1983:153) identified as the drop zone around hearth activity areas.

All sites also produced hammerstones and polishing stones. The hammerstones recovered were all of a small size (<6 cm max length), indicative of tool maintenance and finer stone tool working. Without residue analysis, it is unclear what the polishing stones were used to polish.

Pigment was also recovered from all three sites: ochre from EkNj-4 and EkNj-68 and talc from EkNk-3. While these materials may relate to ceremonial activities, it is unclear whether the presence of this material is of cultural or natural origins since both materials occur naturally in the area.

7.1.2 Faunal and Shell Remains

Faunal material recovered from these sites consisted of fragments of large ungulate (likely *Bison*) from EkNj-4 and a *Bison* carpal from EkNk-3, none of which shows signs of burning. Faunal material was not recovered from EkNj-68. The limited amount of bone recovered may reflect opportunistic resource procurement, although the small sample size makes it difficult to make this inference. The fragmented nature of the bone recovered from EkNj-4 may also be indicative of intensive processing.

Three gastropod taxa were recovered from EkNk-3 immediately below the cultural level (*Valvata tricarinata*, *Stagnicola caperata*, and *Gyraulus parvus* - recovered between 15 and 25 cm DBS). All are aquatic species whose presence indicates semi-permanent water, perhaps in the form of intermittent periods when standing water was present at the site. Today, all are species commonly found in aquatic environments on the Northern Plains. *Valvata tricarinata* (the most common species in the assemblage) is typically found in perennial lakes among vegetation. *Stagnicola caperata* (the second most common species in the assemblage) is most commonly found in temporary-water habitats or on the margins of permanent-water habitats. *Gyraulus parvus* (the least common species in the assemblage) lives on submersed aquatic vegetation in either permanent or temporary water-filled habitats where the bottom is muddy. All three species

can tolerate high levels of salinity although are also found in freshwater habitats (Cvancara 1983).

Considering the preferred aquatic environments of all three species, it seems likely that water levels of Little Manitou Lake were higher than they are today creating a shallow muddy flat in which aquatic vegetation could survive, and thus providing preferred habitat for *Valvata tricarinata* and *Gyraulus parvus* and tolerable habitat for *Stagnicola caperata*. Given their tolerance for saline water habitats, it seems likely that these mollusks relate to a period when the lake was saline in nature, postdating 2,000 years BP when the lake has been postulated to have shifted from a relatively fresh waterbody to a saline environment (see Section 2.2.2).

The presence of these mollusks provides some insight into the paleoenvironmental conditions which existed at EkNk-3 prior to human occupation and contributes to our knowledge of the Holocene mollusk distribution on the Northern Plains (see Section 7.5).

7.1.3 Historic Materials

Very few historic artifacts were recovered during this study. However, both EkNj-4 and EkNk-3 produced lead birdshot pellets.

Evidence suggests that the birdshot pellet recovered from EkNj-4 is contemporary with the lithic materials recovered from the site. The site dates to the Protocontact period (see Sections 7.2 and 7.3), the pellet is of a size which was traded to aboriginal groups in the parkland and grasslands regions of Canada (Ray 1998) (see Section 5.1.2.3), it is badly degraded, and it was found in association with lithic debitage between 10 to 15 cm below surface. Further subsurface investigations and/or metal detecting at this site with a goal to locate other historic materials could help test this hypothesis.

Conversely, the birdshot pellets recovered from EkNk-3 are believed to be historic/modern in origin. They were recovered from the sod layer and were not found in association with lithic materials recovered from this site. The site location at the western end of Little Manitou Lake is well known for its excellent duck hunting during the autumn months; the pellets are likely related to such activities.

7.1.4 Paleobotanicals

Paleobotanical analysis of archaeological samples from sites found throughout the Northern Plains and Rocky Mountain regions has proven to be valuable in interpreting prehistoric settlement and subsistence patterns as well as assisting in paleoenvironmental reconstructions (Aaberg et al. 2003; Benn 1974; Fredlund et al. 1985; Nickel 1977). While plant macrofossils can be attributed to diet-related activities, they can also elucidate non-subsistence cultural activities at some sites where plants may have been used for medicinal remedies, in ceremonies, or for structural purposes. The availability of such resources could have played a crucial role in the selection of residential sites. However, ethnobotanical evidence from archaeological sites often only serves as a guide indicating the local presence and potential for utilization of recovered plant species, not as conclusive evidence that the resources were used. Charcoal recovered from archaeological sites often represents the use of that type of wood as fuel, however, some trees and shrubs also had utilitarian and medicinal uses (e.g., *Alnus* and *Juniperus* [MacKinnon et al. 2009]).

While both modern and prehistoric seeds are commonly recovered from archaeological sites (Minnis 1981), efforts were made to eliminate modern seeds from the seed assemblage considered for this study. Any non-charred seeds encountered during analysis were eliminated with the view that they were likely modern in origin (Keepax 1977; Minnis 1981). In addition, modern seeds which present as charred (namely chenopodium whose black exterior can often be confused as charring) were either broken or crushed to verify charring. Despite these efforts, there remains a possibility that some of the charred paleobotanicals recovered represent plant species which may not reflect direct prehistoric resource use. Seeds and charcoal can become incorporated into the archaeological record through indirect means or locally occurring seeds can be blown into a hearth and burned and may not reflect dietary patterns (Minnis 1981). Seeds can also be added to sites via seed rain but the probability of charred seed rain is low, therefore it is anticipated that material introduced via seed rain would be eliminated as uncharred (Keepax 1977; Minnis 1981). With the hypothesis that recovered paleobotanicals represent culturally introduced materials, plant species recovered during this study are described here to provide an ethnobotanical background for discussing the macroremains which were recovered.

Recovered Paleobotanicals

***Chenopodium* sp. (goosefoot)** seeds were recovered from EkNj-4, EkNj-68, and EkNk-3 (Chapter 5). Over ten species of *Chenopodium* are found throughout the Canadian prairies (Budd and Best 1969). It is commonly found in pastures, waste places/disturbed ground, and on stony hills. It is found throughout North America and is an opportunistic weedy plant, often establishing itself rapidly in disturbed areas (Gray and Fernald 1987; Kindscher 1987; Marles et al. 2008). Chenopods were resources gathered for their tender spring greens and fall seeds (Gilmore 1991; Kindscher 1987). *Chenopodium* leaves are rich in vitamins A and C (Rogers 1980:66) and were consumed fresh or used as potherbs (Blankinship 1905; Gilmore 1913; Johnston 1962). The seeds, which are produced in large quantities in the late summer and fall, could be eaten raw but were more commonly included within stews or parched and ground to make a variety of mushes and cakes (Blankinship 1905; Gilmore 1913; Johnston 1962). Johnston (1970) reported that the Blackfeet were utilizing the seeds of this plant during the Protocontact period or very Late Precontact. Archaeologically, it is one of the most common seed species found on the Plains and many other parts of North America (Aaberg et al. 2003).

Single seeds of ***Polygonum* sp. (knotweed)** were recovered from EkNj-68 and EkNk-3 (Chapter 5). About sixteen species of *Polygonum* are found throughout the Canadian prairies (Budd and Best 1969) and are widespread throughout North America (Marles et al. 2008). *Polygonum* plants are found in a variety of habitats including moist areas on mud flats, slough margins and lake shores, including saline environments, but can tolerate dry and rocky areas as well (Marles et al. 2008). The leaves and young stems of some species were collected in the spring and used raw in salads or cooked (Rogers 1980). The roots of some species are starchy and could be roasted. Seeds were parched and ground into a meal. Archaeologically, *Polygonum* seeds are often found in association with *Chenopodium* seeds, both of which are believed to have been important food resources (Kindscher 1987). The leaves and stems of some species contain tannins that make the herb useful for treating inflammations of the mouth and throat (Marles et al. 2008).

Poaceae (grass family) seeds were recovered from EkNj-4 and EkNk-3 (see Chapter 5). The most common plant groups growing on the prairies are grasses (Kindscher 1987). While wild grasses have edible seeds, most wild species have small seeds which are tightly enclosed in inedible scales which are difficult to remove. As such, wild grass seeds generally were not a

major food source. However, when used as a food source, grains were often parched and ground into a meal to be used to make mushes and cakes after the seeds were threshed and winnowed. Grasses have also been reported to have been used as floor coverings, tinder, basketry material, and to make brushes and brooms (Rogers 1980). A particularly important grass species on the Plains from a cultural perspective was sweetgrass (*Hierochloa odorata*). The species has been ethnographically documented to have been used as an element of ceremonial events such as its inclusion in vision quest bundles and for smudging, with sweetgrass ethnographically documented as the most common form of incense used by Plains groups (Lowie 1963; Shillibeer 1995). Given the identification of eight ceremonial sites around the western end of Little Manitou Lake, it is possible that Poaceae seeds recovered at these sites may be related to the use of sweetgrass during such activities, although species identification was not possible for the recovered seeds.

***Scirpus* sp. (bullrush)** seeds were recovered from EkNj-4 and EkNk-3 (see Chapter 5). About half a dozen species of *Scirpus* are found on the Canadian Prairies, in moist to aquatic environments, often forming extensive borders around sloughs, ponds, lakes and in roadside ditches (Budd and Best 1969). Many parts of this plant were used, with various parts being collected through the year. As a food source, the plant is a rich source of nutrients. In the spring, young shoots and leaf bases were peeled and the inner portions eaten raw or cooked. During the summer, flowers were eaten alone or added as flavouring or thickener for other foods. Pollen-rich flowers and the pollen itself were collected and used as a flour, either along with or mixed with other meal. In the fall, the rootstalks were collected and peeled and the white inner cores of almost pure starch were eaten raw, boiled, baked, or dried and ground into flour. Fresh green leaves were woven into mats and baskets (Gilmore 1991; Marles et al. 2008; Rogers 1980).

A single ***Trifolium* sp. (clover)** seed was recovered from EkNj-68 (see Chapter 5). *Trifolium* sp. is commonly found in waste places and along roadsides across most of North America (Marles et al. 2008). Three species are known to grow in the Canadian Prairie provinces, however they have been introduced as a result of cultivation (Budd et al. 1987). Therefore, it seems likely that this seed was introduced to the site at a later date, perhaps as a result of a grass fire. Although ethnobotanical uses of *Trifolium* have been documented (see Marles et al. 2008 and Rogers 1980) these will not be discussed here given the likelihood that this seed is not contemporaneous with the archaeological deposits at the site.

A single seed that compares favourably to ***Mammillaria* sp. (pincushion cactus)** was recovered from EkNk-3 (see Chapter 5). Only one variety of *Mammillaria* (*M. vivipara*, also known as *Escobaria vivipara*) is found on the Canadian Prairies. It is a pincushion-like cactus with bright pinkish-purple flowers that appear in early summer. Fruits of this species are pale-green, fleshy berries about 1.2 cm long which turn brown with age and are very sweet and edible when ripe (Budd and Best 1969). *Mammillaria vivipara* is found on the open prairie of Saskatchewan particularly on dry, usually sandy exposed hillsides and ridges in the grassland region of southern Saskatchewan from the United States border north to Saskatoon (Budd and Best 1969; Harms 1983). Harms (1983) notes that the indigenous people of Saskatchewan ate the fleshy, juicy fruits of *Mammillaria vivipara* as part of their diets. Puseman et al. (1999) note that the fruits of *Mammillaria* sp. were eaten fresh, cooked, or dried for future use. Seeds were eaten in soups or dried, parched, and ground into a meal to be used in gruel or cakes. Hellson (1974:103) writes, "The fruits of these 'wild figs' were eaten as a confection". The Blackfeet were known to use the fruit of this plant as a drug and as food (Johnston 1970).

A single seed that compares favourably to ***Mentzelia* sp. (sand-lily)** was recovered from EkNj-68 (see Chapter 5). One variety of *Mentzelia* (*M. decapetala*) is found in the Canadian Prairie provinces, typically on dry gravelly eroding hillsides and clay banks (Budd and Best 1969; Kindscher 1987). The fruits of this species are oblong capsules about 4 cm long and up to 1.2 cm thick opening on the top and containing many seeds (Budd and Best 1969). Seeds, which are small and oily, could be parched and ground into a fine, sweet meal (Kindscher 1987; Rogers 1980).

Three seeds that compare favourable to ***Aster* sp. (aster/daisy)** were recovered from EkNk-3 (see Chapter 5). According to Budd and Best (1969), 20 species of *Aster* are found on the Canadian Prairies. These species are typically perennial or biennial herbs that flower in later summer and early fall. They are found in a wide range of habitats including river valleys, roadsides, woodlands, dry open prairies, moist ground, and on dry, saline, and/or gravelly soils. The Cree were known to use the root of *Aster laevis* in their traditional medicine for toothaches and the whole plant was used to strengthen mothers after giving birth (Keane and Howarth 2003). *Aster laevis* is a late blooming aster with star-like flowers with purple ray florets shooting out of a bright yellow centre. It is found in shrubby areas and was observed growing in the Little Manitou Lake area. According to Gilmore (1991), the Pawnee used an unidentified variety of

Aster, known colloquially as Prairie Aster, as a moxa (a material placed on the skin and ignited for use as a counterirritant). The stems were burned to produce small pieces of charcoal which were applied to the skin over the affected area and fired.

Charcoal from the **Salicaceae (Willow) family** was recovered from EkNj-4 (Chapter 5). The Salicaceae family includes both *Salix* (willow) and *Populus* (poplar, aspen, cottonwood). There are nine known species of *Salix* and five known species of *Populus* common to the Canadian Prairie provinces (Budd et al. 1987). These species are commonly found along rivers and streams, near water, and on wet or moist ground. They would likely have been found in the coulees and along the shoreline of Little Manitou Lake. All members of the willow family have anti-inflammatory and pain relieving properties found in the cambium layer of the bark (similar to the synthetic chemicals in Aspirin). The bark of aspen (*Populus tremuloides*) was often used in traditional medicine as an emetic to purge the ill. Similarly, the buds of Balsam poplar (*Populus balsamifera*) were used to make a healing salve mixed with oil and beeswax and were used to help reduce pain, fever, and inflammation. The Cree used the inner bark of *Populus balsamifera* ceremonially for lighting pipes, and singers used a tincture of balsam buds to alleviate throat soreness caused by intense singing (Keane and Howarth 2003). *Salix* was used for a variety of medicinal and utilitarian purposes. In addition to the pain relieving properties of the bark, its flexible branches were used as frameworks for sweat-lodges and in basketry (Gilmore 1991; Rogers 1980).

Charcoal from ***Alnus* sp. (alder)** was recovered from EkNj-4 and EkNk-3 (Chapter 5). There are two species of *Alnus* common to the Canadian Prairie provinces often found along streams, rivers, or lake shores or on the fringe areas of dry coniferous forests (Budd et al. 1987). *Alnus* was used both for medicinal and utilitarian purposes. The catkins were boiled for treating venereal disease, the stem boiled to make an emetic for treating upset stomach, and the roots boiled to make a drink to relieve menstrual cramps (Marles et al. 2008). Alder bark and stems were also boiled to make a red-brown dye. The wood could be used to make pipes and small bows for bird or squirrel hunting. The dried wood could be burned to smoke meat and rotten wood could be burned to smoke hides for tanning or to keep mosquitoes at bay.

Paleobotanical Summary

Relatively few macroremains were recovered from EkNj-68 (8 seeds/seed fragments and 278 very fragmented and unidentifiable charcoal particles) compared with EkNj-4 and EkNk-3. This is consistent with the more ephemeral nature of the hearth at this site and a generally lower recovery of charred hearth deposits (Section 5.2.2). The recovered macroremains from this site therefore only provide a limited view of plant resources that may have been used and/or present.

Some indications of seasonality can be inferred from the macrofossils recovered from these sites. In general, charred seeds indicate a summer/early fall occupation at these sites as this is when the seeds would have been produced. *Chenopodium* sp. typically produce seeds in late summer/early fall and could have been introduced into the archaeological records at EkNj-4, EkNj-68, and EkNk-3 either as direct resource use or indirectly.

Not surprisingly, grass (Poaceae) seeds were recovered from two of the sites (EkNj-4 and EkNk-3). Given the placement of these sites in the Mixed-Grassland Prairie ecoregion of the province, grasses would have been naturally occurring at these sites. Given the importance of sweetgrass by Plains groups for ceremonial activities and the close proximity of ceremonial sites near EkNj-4 and EkNk-3, it is possible that the seeds recovered were from this species. Whether grass species were being used culturally or were introduced to the sites indirectly is unclear, although either is possible.

The three seeds that compare favourably to *Aster* sp. which were recovered from EkNk-3 also suggest a late summer/early fall occupation as seeds of these species often mature at this time of year. Although these seeds may suggest cultural use of this plant, given the method of seed dispersion employed by many *Aster* species (seed-like achenes topped with parachute-like silky white hairs), it is possible that they were introduced to the site indirectly as they can move by wind over great distances (Beal 1898). Similarly, *Scirpus* sp. seeds, which were recovered from EkNj-4 and EkNk-3, mature in the summery/early fall and can also be dispersed by wind (Nathan et al. 2008).

The low recovery of *Polygonum* sp. seeds may suggest indirect deposition at EkNj-68 and EkNk-3 although there is a possibility that this plant resource was being utilized or growing at these sites. This is also true for the single *Mentzelia* sp. seed recovered from EkNj-68. This may also be true for the single seed that compares favourably to *Mammillaria* sp. which was recovered from EkNk-3. However, given the low-lying topography of the site immediately

adjacent to the lake, which does not align with typical habitat for *Mammillaria*, it seems likely that this plant was not growing in the immediate area and may have been transported to the site.

Charcoal from the Salicaceae family (willow/poplar/aspen) was only recovered from EkNj-4 while charcoal from *Alnus* sp. was recovered from both EkNj-4 and EkNk-3. It is likely that these tree species were obtained from nearby coulees and used as fuel sources although they could have served utilitarian purposes as well (as described above), such as the construction of sweat lodges (willow). Charcoal recovered from EkNj-68 was too fragmented for identification.

7.1.5 Hearths

Hearths identified at all three excavated sites were found to be located either outside or immediately adjacent to stone circles. The hearth at EkNk-3 is situated approximately 2 m northwest of stone circle 2, while the hearths at EkNj-4 and EkNj-68 are situated on the edges of the associated rings: the hearth at EkNj-4 being on the northwestern edge of stone circle 7 and the hearth at EkNj-68 being on the western edge of stone circle 11. The evaluation of the magnetometry results collected at these sites reveals that only a few of the fourteen rings analyzed are likely to contain interior hearth features (see Appendix A). Features 6 and 50 at EkNj-4 and Features 13 and 14 at EkNj-68 are the only rings to return results indicative of the possible presence of an interior hearth. All other recorded anomalies either fall on the edges or outside of ring features. Without further excavations to explore these anomalies, it is difficult to say whether these interior anomalies represent hearths/burning events or if they represent buried igneous rocks which can produce a similar signal.

Similarly, Brumley and Dau (1988) found only a few stone circles in open, exposed locations in the Forty Mile Coulee area of Alberta contained interior hearths (see Figure 3.1-2). They postulate that this lack of interior hearths could suggest the use of these sites during the warmer season, perhaps during the summer or early fall, when cooking and smudge fires were made outside the dwellings. This is further supported by Tom Kehoe's research with the Blackfoot: one of his informants noted that the "family cooked inside the lodge only during bad weather, using the outside fireplace most of the year. This...was the reason for the absence of a rock-lined hearth or charcoal remains inside the tipi" (Kehoe 1960:431-432). Based on research carried out in North Dakota, Fredlund et al. (1985) further postulated that hearths and other features are often found in areas surrounding ring features, noting they are likely to occur

between 3 to 6 m from the outer edges of rings (see also Deaver [1983] and Graspointner [1980] for similar findings in Montana and Alberta). While the hearth at EkNk-3 is situated somewhat closer to the adjacent ring feature than the estimated 3 to 6 m suggested by Fredlund et al. (1985), it is likely that it served as an outdoor activity area, possibly used during the warmer seasons.

Unlike the hearth at EkNk-3, the hearths identified at EkNj-4 and EkNj-68 were both situated on the peripheries of stone circles. Finnigan and Johnson (1984) have postulated that hearths situated on the edges of rings may have been used as smudge fires while the sides of the dwellings were raised to keep insects out without heating the interior. Today, the prevailing summer wind in the Little Manitou Lake area comes from the west or northwest which would support the hypothesis of blowing smoke through a structure to keep bugs at bay, assuming wind direction was similar during site occupation. Conversely, Deaver and Deaver (1987) postulate such positioning of hearths could also reflect multiple site occupations and coincidental placement of later rings on earlier buried hearths. While this is a possibility at both sites, it is difficult to verify given the absence of stratigraphic data needed to identify multiple occupations.

The hearth at EkNj-4 was distinctly basin-shaped and was interpreted as a pit hearth. The hearth feature contained charcoal with a few unburned bone fragments and lithic debitage found on the periphery as well as a hand-sized cobble (identified as a polishing stone) which had some blackening on one side. The hearth at EkNk-3 received two differing interrelations (see Section 5.3.2 for additional information), one based on excavation data and the other on POSL data. Observations made during excavation and data which were recovered suggest a basin-shaped pit hearth while POSL data suggest a surface hearth which resulted in a basin-like soil stain due to surface heating below the hearth location (similar instances have been observed elsewhere on the northern Plains; *cf.*, Gilliland et al. 2016). It is possible that multiple occupations occurred at this site and may have resulted in both an earlier pit hearth and a latter surface hearth. Further excavations at the site may help to substantiate these interpretations. Regardless, the hearth at EkNk-3 contained charcoal, fire-cracked rock, fire-reddened soil, an ash lens toward the base of the hearth, and an unburned bone on the periphery. At both EkNj-4 and EkNk-3, charcoal was diffuse and mixed with soil. Pit hearths have been discovered across the Northern Plains (*cf.*, Damkjar 2003; Reeves 1983b; Wandsnider 1997; Wilson 1984) and were a common cooking method (Brink 2008; Mandelbaum 1979). Wandsnider (1997) suggests that pit-hearths were

often employed when meat and plant foodstuffs were cooked for extended periods of time and subject to moderate to high heat.

It seems likely that these hearths were used for cooking and processing food resources. The presence of bison bone adjacent to both hearths evidences that these pit hearths may have been used to process bison. Fire broken rock was recovered from EkNk-3 which could have been used in cooking/boiling activities. It is unclear what the purpose of the large fine-grained quartzite cobble (EkNj-4:8) would have been which was found in the hearth at EkNj-4. Although quartzite cobbles are ideally suited for stone boiling activities, the cobble is missing evidence of spalling/fracturing indicative of repeated heating events typically associated with rocks used in boiling pits (Backhouse and Johnson 2007; Brink and Dawe 2003). One side (the side that was facing down when recovered) has some evidence of blackening and the stone has been smoothed on some of its surfaces. Without residue analysis, it is unclear what this stone would have been used for and why it was recovered from the hearth at this site.

Unlike the well defined basin-shaped hearths described above, the hearth at EkNj-68 was much more ephemeral in nature. It was identified primarily through the observed presence of charcoal flecks and blackened soil. Although it has a slight basin-shape, it is poorly defined and is shallower than those found at EkNj-4 and EkNk-3, possibly representing an unbound surface hearth. Very few artifacts, few paleobotanicals, and no faunal material were recovered from this site; the primary function of this hearth feature remains unclear. Unbound (lacking exterior rocks) and poorly defined surface hearths, often evidenced by charcoal staining and reddened soil, are commonly found throughout the Northern Plains (*cf.*, Adams 1978; Wilson 1984).

7.2 Radiocarbon Dates

One of the successes of this research project was the identification of hearth features and the recovery of charred organics (discussed above) which provided absolute dates for features at the sites under investigation. As noted in Chapter 3, research on stone circle sites has been plagued by the paucity of securely dated sites and the effort often required to recover datable organics. The dates for EkNj-4, EkNj-68, and EkNk-3 outlined in Chapter 5 provide insight into when these sites were occupied. Even with this success, a few points must first be explored before accepting or rejecting the results of the radiocarbon analysis for these sites.

Datable material from stone circle sites on the Northern Plains is often recovered from shallow cultural deposits (*cf.*, Dasovich 1998; Lewarch et al. 1998) which can influence the confidence placed in the results of radiocarbon dating, as was the case for all sites excavated for this study. The likelihood of contamination from overlying soils/surficial materials is increased with the recovery of shallow deposits (Birkeland 1999; Holliday 2004). Soil at all three sites also showed at least some signs of vertic action which could have caused the vertical dislocation of carbon, either older or newer (Birkeland 1999), despite the fact that all charcoal subject to radiocarbon dating for this study was obtained from *in situ* hearth deposits and therefore anticipated to accurately reflect the date of occupation and/or use of associated features.

In addition, the radiocarbon dates from EkNj-4 and EkNj-68 (EkNj-4: 158 ± 20 and 160 ± 19 yrs BP; EkNj-68: 121 ± 22 yrs BP) fall within a time period which is unreliably dated by radiometrics (see Sections 5.1.3 and 5.2.3). Material dating to the last 300 years is difficult to calibrate to conventional and unambiguous calendar age estimates due to the increased burning of fossil fuels which add dead CO_2 to the atmosphere (known as the Suess or Industrial Effect) thereby skewing conventional calibration methods (Taylor 1987). In addition, material with a conventional C^{14} value from the last 200 years may be reported as *modern* (as may be the case for sample C10 analyzed from EkNk-3; see Section 5.3.3) due to a combination of the Suess Effect and the Nuclear Effect (or Atomic Bomb Effect) which skewed the C^{14} concentrations in the atmosphere as a result of the detonation of thermonuclear devices post-World War II.

Despite these factors, samples were collected from *in situ* hearths and found with archaeological assemblages and therefore are considered to reflect the true dates of site occupation. While the protocontact period in Saskatchewan remains relatively poorly documented, both from an archaeological and written records perspective, a number of stone circle sites from across the Northern Plains which also have shallow deposits have been securely dated to the last 300 years (Table 7.2-1 and Figure 7.2-1). Many of these sites have produced diagnostic artifacts which have helped to corroborate radiocarbon results. Given the similarities in circumstances between these sites and those of the current study, the successful dating of these comparable sites provides more confidence in accepting the radiocarbon dates obtained during this study. Table 7.2-1 includes a summary of shallow stone circle sites which have been dated by radiometrics to the Late Precontact and Protocontact periods in Saskatchewan and Alberta (illustrated in Figure 7.2-1). The material culture recovered from EkNj-4, EkNj-68, and EkNk-3,

discussed previously and in Chapter 5, also provides some confidence that the sites predate direct European contact given the presence of lithic debitage related to the production and maintenance of stone tools and the general lack of European goods (with the exception of the birdshot pellet from EkNj-4). Further work at these sites may produce diagnostic artifacts, ceramics, or other datable material which could help to corroborate the radiocarbon results.

Table 7.2-1. Stone circle sites on the Northern Plains dated to the late Precontact and Protocontact periods.

Site	Province	Sample Type	Conventional C14 Age	Calibrated Date	Sample Depth (DBS)	Reference
DkMr-34	SK	collagen	360 +/- 40	AD 1440-1640	0-10 cm	Young and Markowski (2009)
EeNj-2 (Morris Church)	SK	charcoal	260 +/- 50 780 +/-50	AD 1181 ± 50	n/a	(Millar and Gromadko 1981:4) Kehoe and Kehoe (1968:31) CARD 2.1 (2016)
EkNj-4	SK	charcoal	158 +/- 20 160 +/- 19	AD 1667-1954	6-7 cm 8-9 cm	This thesis: Appendix D
EkNj-68	SK	charcoal	121 +/- 22	AD 1681-1954	12-15 cm	This thesis: Appendix D
EkNk-3 (L2) (L5)	SK	charcoal	modern 326 +/- 34	n/a AD 1472-1645	7-10 cm 20-25 cm	This thesis: Appendix D
DjPm-44	AB	collagen	100 +/- 90	AD 1660-1960	7-29 cm	Van Dyke (1994:208)
DjOu-31 (SC3) (Forty Mile Coulee)	AB	collagen	470 +/- 150	AD 1200-1850 AD 1900-2000	0-30 cm	Brumley and Dau (1988:241) Dau and Brumley (1987)
DjOu-60 (SC12) (Forty Mile Coulee)	AB	collagen	320 +/- 60 modern	AD 1440-1670 AD 1780-1800 n/a	0-20 cm	Brumley and Dau (1988:243) Dau and Brumley (1987)
DIPb-13 (SC48) (Cranford East)	AB	collagen	310 +/-50	AD 1460-1670	10-20 cm	Damkjar (2003)
EfOp-324	AB	charcoal	275 +/- 80	AD 1400-2000	8-16 cm	Adams (1978) CARD 2.1 (2016)

Data and reports were provided by the Saskatchewan Archaeological Resource Management Section and the Archaeological Survey of Alberta. The list of sites provided here is not exhaustive but is provided for comparative purposes only.

One other note should be made about the radiocarbon dates obtained from these sites. As noted in Section 3.1.1.3, researchers often struggle with discerning individual use episodes at stone circle sites due to low rates of sedimentation, which can result in artifacts and features from several occupation events being collapsed into a single deposit lacking vertical stratigraphic separation. This can be problematic when seeking to date site occupation(s). Deaver (1989:259)

notes that while absolute dates provide some information on temporal site associations, "they are inadequate for demonstrating all occupations". This is indeed true for the sites investigated for this study since only small areas at each of the sites were subject to subsurface investigation and therefore absolute dates of charcoal obtained from the hearths identified at these sites only speak to the use and occupation of associated features.

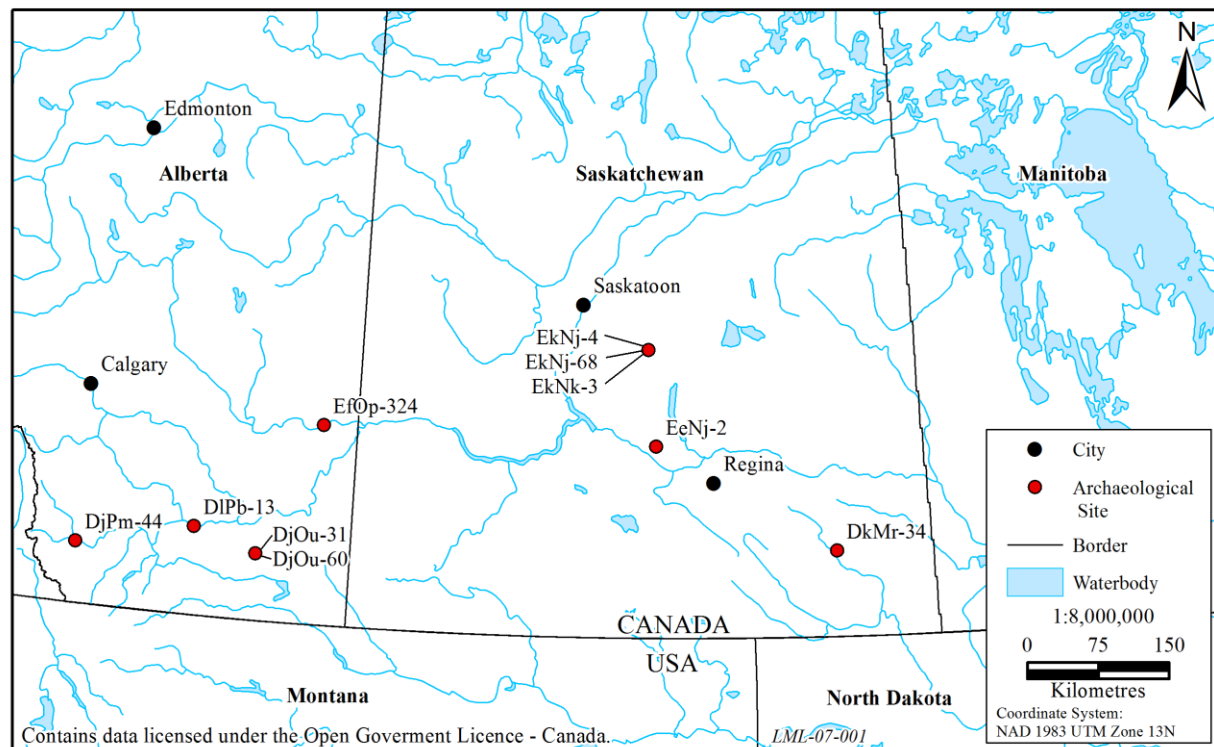


Figure 7.2-1. Selected stone circle sites on the Northern Plains dated to the late Precontact and Protocontact periods.

7.3 Site Occupation

Accepting the radiocarbon dates from the sites/features investigated during this study places occupation during the Late Precontact and Protocontact periods. EkNj-4 and EkNj-68 date to the Mortlach phase of Saskatchewan's prehistory. Conversely, EkNk-3, which was occupied some 200 years earlier than the other sites under investigation, dates to a transitional time between the Late Precontact-Protocontact periods, possibly during the late manifestation of Old Women's phase in Saskatchewan or the early introduction of the Mortlach phase. Consequently, these two periods of occupation will be briefly discussed below.

7.3.1 EkNj-4 and EkNj-68 and Mortlach Phase

Radiocarbon dates from EkNj-4 (ca. AD 1670; 158 ± 20 yrs BP and 160 ± 19 yrs BP) and EkNj-68 (ca. AD 1680; 121 ± 22 yrs BP) (see Chapter 5) place site occupation at these sites during the Protocontact period, during the Mortlach phase in south-central Saskatchewan (Figure 3-1). This phase is characterized as one containing Plains Side-notched points and ceramics which show attributes derived from the Middle Missouri and/or Selkirk styles (Meyer 1988; Vickers 1994).

Geographically, the range of the Mortlach phase has been reasonably well defined, centered in southern Saskatchewan west to the South Saskatchewan River and taking in parts of southwestern Manitoba, northern North Dakota, and northeastern Montana (Figure 7.3-1 - inset; Walde 2004). Temporally, the Mortlach phase has been described as the "terminal prehistoric phase in its district" (Joyes 1973:83; Walde 2003). In Saskatchewan, the Plains Side-Notched point style appears about AD 1300 (650 yr cal BP) and persisted until European contact (typically defined as AD 1750) (Figure 3-1; Vickers 1994). The expression of this point series found in southeastern Saskatchewan has been reclassified by Peck and Ives (2001) with the Mortlach Group subclass used for points that are found in close association with Mortlach ceramics from sites that date between AD 1300 to European contact.

Walde et al. (1995) state that "Absolute dates for the Mortlach Phase continue to be rare and it is clear that a great deal more work must be accomplished before the dating of the Mortlach Phase can be considered reasonably secure" (1995:43). However, a growing body of data suggest that it had a limited temporal span from approximately AD 1500 to European contact (Walde 2003), slightly later than the date proposed by Peck and Ives (2001) for the associated point sequence (AD 1300).

Geographically, Walde (2003) points out that due to participation in different exchange networks between parkland and grassland groups, subdivision of the Mortlach phase is warranted. This division coincides roughly with the southern boundary of the parklands in central Saskatchewan. For the parkland expression of Mortlach, Meyer (1984:45) suggested the "Lozinsky complex" which Walde (2003:62) re-coined as the "Lozinsky Subphase" (although the terms "Wascana" [Kehoe 1959] and "Moose Jaw" [Malainey 1991] have also been used [Walde 2003:62; Nicholson et al. 2011:156]). The expression of this subphase is based largely on collections from the Lozinsky site (FdNm-51, formerly FdNn-6; Figure 7.3-1 - inset) which

contains Mortlach-style pottery as well as Selkirk-style ceramics. Sites within the Little Manitou Lake region which contain Lozinsky subphase ceramics include Elni-1, Elni-2, EjNg-3, and EkNg-29¹ (Figure 7.3-1; Carlson 1993; Malainey 1991; Walde 2003). For the grassland

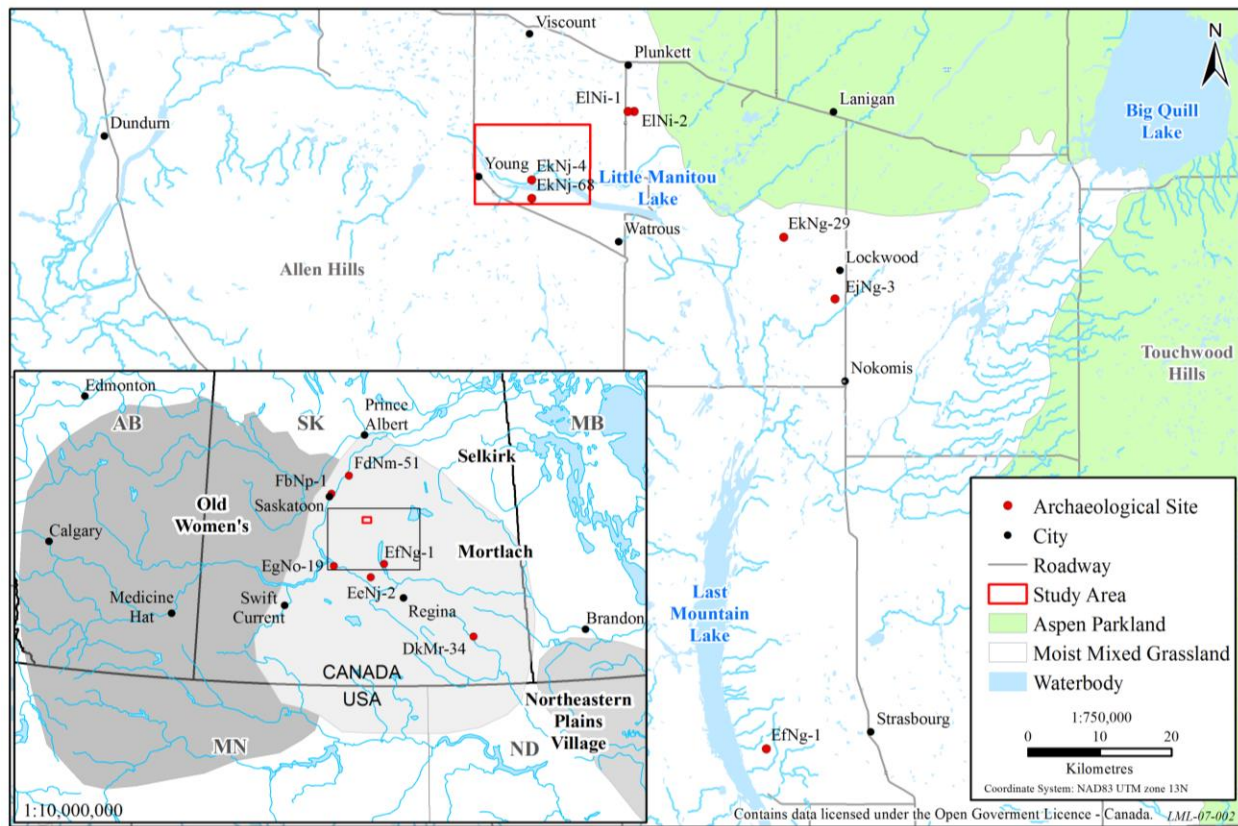


Figure 7.3-1. Approximate geographic range of the Mortlach phase, ca. AD 1300-1750 (after Nicholson et al. 2011:157; Walde et al. 1995:33) and archaeological sites dated to this phase discussed in this chapter.

expression of Mortlach, Walde (2003:62) has suggested the "Lake Midden Subphase", rather than "Fall River" as suggested by Wettlaufer and Mayer-Oakes (1960) as Walde felt Fall River was too mired in controversy over the ethnic origins of the Mortlach people. The expression of this subphase is based largely on collections from the Lake Midden Site (EfNg-1 - see Figure 7.3-1; Walde 2003; Watrall 1979) which contains Mortlach-style pottery as well as ceramics with Middle Missouri and/or Plains Village ware characteristics. No other sites in the Little Manitou Lake region have been found to contain Lake Midden subphase ceramics.

From a lithic material perspective, Walde (2003:51-55) suggests that people reflected by the Lozinsky Subphase were likely not participating in the lithic exchange network established

¹ Note that both Walde and Malainey refer to this site as the Schraeder Site and that Walde has documented it as EkNj-9, likely a typo. According to the SARR for this site it is documented as EkNj-29 - the Schoeder Pipe Site.

by their southern neighbours, despite the close stylistic similarities in their pottery with that of their southern Lake Midden Subphase counterparts. Conversely, Lake Midden Subphase deposits typically have large amounts of Knife River flint tools but a relative paucity of debitage of this material, suggesting that formed tools, such as the large quantity of Knife River flint endscrapers found at EfNg-1 (Lake Midden), were traded into the area from the south and not manufactured locally (Walde 2003). Other material types typically observed at Mortlach sites include Swan River chert, fused shale, silicified peat, and local cherts.

Since the Little Manitou Lake sites are situated close to the grassland-parkland border (currently just 20 km to the east; see Figure 7.3-1) but also close to a key site for the Lake Midden Subphase (EfNg-1; approximately 80 km to the southeast) it is difficult to say if they represent either the northern or southern expression of Mortlach subphases. Evidence presented by Walde (2003:51-55) indicates that Little Manitou Lake is on the peripheral edges of these two subgroups. Neither pottery nor diagnostic artifacts were recovered during excavations, possibly due to the small sample size, which would help assign site occupation to a particular Mortlach subphase. The absence of Knife River flint from the lithic assemblages of EkNj-4 and EkNj-68 may indicate that site occupation was more aligned with the northern Lozinsky subphase of Mortlach, however, this is uncertain since the artifact collections from the study sites are very small. Ceramics indicative of the Lozinsky subphase have also been found at sites within the Little Manitou Lake region (described previously in this section) which helps to support this supposition.

7.3.2 EkNk-3 and Late Old Women's/Mortlach Transition

The radiocarbon date from EkNk-3 places the occupation of this site around ca. AD 1470 (326 +/-34 yrs BP) during the Late Precontact period (see Chapter 5 and Figure 3-1). This correlates roughly with the terminus of the Old Women's phase in central Saskatchewan. This phase is characterized as one containing ceramics, projectile points of either Prairie Side-Notched or Plains Side-Notched types, and an emphasis on locally available lithics in which bipolar reduction techniques are common (Brumley and Dau 1988; Meyer 1988; Peck and Hudecek-Cuffe 2003; Reeves 1983a). Because of the presence of both Prairie and Plains Side-Notched points, two sequential expressions of this phase have been proposed: an earlier form which includes Prairie Side-Notched points and a later expression with increasing numbers of

Plains Side-Notched points, although the Prairie Side-Notched points are never replaced completely (Meyer 1988; Reeves 1983a). The ceramics characteristic of this phase have been suggested to include Late Variant Saskatchewan Basin Complex variety and/or Ethridge Ware in Alberta (Brumley and Dau 1988; Meyer 1988). In addition, Moose Jaw culture ceramics in central Saskatchewan, which Malainey (1991:9) has described as the preceding occupation to the Mortlach phase, also reflects similar stylistic characteristics (Malainey 1991; Meyer 1988; Reeves 1983a).

Temporally, there is some variation in estimates regarding when the Old Women's phase ended and the Mortlach phase began in central Saskatchewan. Meyer and Epp (1990) suggest that the end of the Old Women's phase and start of the Mortlach phase in central Saskatchewan occurred around AD 1450, which falls within one standard deviation for the date obtained from EkNk-3. Walde (2003) suggests that this transition occurred about AD 1500, which also falls within one standard deviation for the EkNk-3 date. Thus, EkNk-3 can be seen to date to the transition. On the other hand, Nicholson et al. (2011) indicate that the dominant occupation in central Saskatchewan between ca. AD 800 and AD 1300 was the Old Women's phase which was replaced by the Mortlach phase from the south and east, positioning the end of this phase approximately 170 years before the dated occupation at EkNk-3. Walde et al. (1995:34) state that "In addition to regional diversity, temporal diversity may also be suggested in the Old Women's phase...[which] covers a time period of almost 1,100 years, overlapping not only the end of the Avonlea phase, but also spreading well into the Indirect Contact period and perhaps into Contact period as well". The ambiguity of the temporal framework for this phase also complicates our understanding of its geographic range due to localized and perhaps staggered westward movement. Figure 7.3-2 illustrates an estimated geographic range of the Old Women's phase between AD 800-1300; the eastern edge of this phase has been postulated to have shifted west as the Mortlach phase moved into the region (see Figure 7.3-1 - inset). Researchers have suggested that the later expression of the Old Women's phase became restricted to the region west of the South Saskatchewan River/Saskatoon area, although due to the presence of the Old Women's phase "over a huge section of the northern plains, it is expected that regional differences would develop" (Walde et al. 1995:33). Within the Little Manitou Lake region sites ElNi-1, ElNi-2,

EjNg-3, and EkNg-29² (Figure 7.3-2; Carlson 1993; Malainey 1991; Walde 2003) all contain Old Women's phase ceramics, although the ceramic assemblages from this phase have not been studied in detailed and the sites have not been dated.

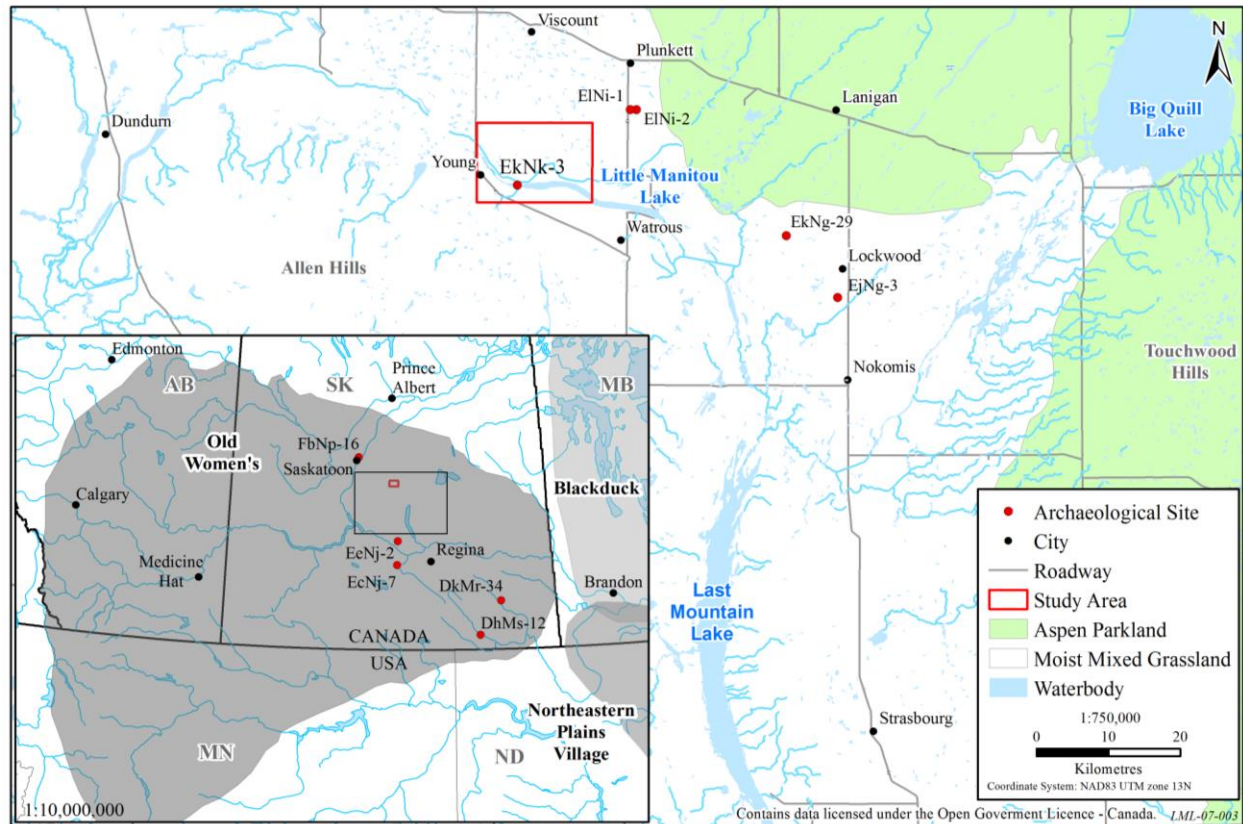


Figure 7.3-2. Approximate geographic range of the Old Women's phase, ca. AD 800-1300 (after Walde et al. 1995:25; Nicholson et al. 2011:130, 154) and archaeological sites dated to this phase discussed in this chapter.

Meyer (1988:60) notes that the later expression (ca. AD 1300-1750 - Late Old Women's; see Figure 7.3-1 - inset) of the Old Women's phase is not well represented in Saskatchewan and as such it is difficult to delineate both its temporal and geographic expression in the province. Not surprisingly, more common to this period are Selkirk and Mortlach component sites. This seems true given dates and material recovered from FbNp-1 (Opimahaw [Tipperary] Creek; Figure 7.3-1 - inset) which produced Mortlach style material dated from 590 ± 75 yrs BP (ca. AD 1360) to <100 yrs BP. However, there are sites which are found in central Saskatchewan which contain assemblages which suggest Late Old Women's phase occupation such as EcNj-7 (Garratt), FbNp-16 (Newo Asiniak), and EeNj-2 (Morris Church - lower level) among others

² Note that both Walde and Malainey refer to this site as the Schraeder Site and that Walde has documented it as EkNj-9, likely a typo. According to the SARR for this site it is documented as EkNj-29 - the Schoeder Pipe Site.

(see Figure 7.3-2; Meyer 1988). These sites typically contain Prairie and Plains Side-notched points (with an increasing frequency of the latter) and Old Women's pottery which is characterized by fairly thick-walled vessels with coarse and poorly consolidated paste being globular with rounded or occasionally flattened bases (Byrne 1973; Meyer 1988).

Walde et al. (1995) note that although bison played a major role in subsistence strategies during the Late Old Women's phase, other species, such as grouse, ducks, and geese were also exploited (i.e., DhMs-12 - Figure 7.3-2 - inset; Magee 1997). Although only one bison bone was found during excavations at EkNk-3, the positioning of the site at the end of Little Manitou Lake would have been ideal for hunting game birds. From personal observations during late summer and autumn at this site, the site is located on an east-west flight path of migratory waterfowl species who rest, forage, and in some cases nest along the lakeshore (see also Section 2.3.1). Presumably, such would have occurred in late precontact times as well.

A commonality of many Late Old Women's phase sites is access to a source of fresh running water (Walde et al. 1995). This is true for EkNk-3 which has fresh water streams to the north and south which feed into Little Manitou Lake, which is important as the lake itself would have been saline at the time of site occupation (see Section 7.5). In fact, the placement of this site immediately adjacent to the Little Manitou lakeshore differs from EkNj-4 and EkNj-68 which are both situated on terraces some 40 m above the current lake level and away from freshwater streams. The positioning of EkNk-3 may perhaps demonstrate the importance of access to freshwater for the site's residents.

Another characteristic of the Old Women's phase is its apparent associations with different rock-feature site-types, namely stone circles and medicine wheels. Although stone circle sites have been assigned to many different occupation periods, Frison et al. (1996) have suggested that stone circle sites are especially characteristic of the Old Women's phase, noting that in some areas of the Plains over half of the stone circles excavated have yielded Old Women's phase material. Peck and Hudecek-Cuffe (2003) suggest that summer (June-September) was a time when people during this period would aggregate for special events. Although they go on to note that archaeological data from this phase have yet to be confidently assigned to summer occupation, researchers have recognized large clusters of tipi rings along waterways, which may be indicative of large summer aggregations. These proposed summer aggregation sites may tie in with a relationship between Old Women's phase sites and medicine

wheels which have been postulated with some well-known sites (such as Majorville Medicine Wheel, British Block Cairn, and Grassy Lake Cairn [Calder 1977; Forbis 1960; Wormington 1965]) containing Late Old Women's phase material (Peck and Hudecek-Cuffe 2003). Given the close proximity of EkNk-3 to eight ceremonial sites which have been documented at the western end of Little Manitou Lake, including two medicine wheel sites (EkNj-5 and EkNj-22) and a significant glacial erratic site (EkNk-4), a correlation might be drawn between the summer/early fall occupation/aggregation at Little Manitou Lake and use of adjacent ceremonial sites (see also Section 7.4.2).

In terms of raw lithic materials, while Old Women's phase has been generally characterized as showing a strong emphasis on locally available lithics (Meyer 1988; Reeves 1983a), researchers have reported a higher frequency of obsidian and petrified wood in later Old Women's phase sites, while Swan River chert appears to dominate earlier Old Women's phase assemblages (Walde et al. 1995). The paucity of cultural materials recovered from EkNk-3 makes it difficult to draw many conclusions, except that the lithic assemblage from this site contained a range of locally available raw materials. Swan River chert is present in the assemblage but at a lower percentage than any other material, with quartzite, local chert, and siltstone making up the majority of material types recovered; obsidian and petrified wood are both absent from the collection (see Sections 5.3.2.1 and 7.1.1).

Because of the ambiguity which surrounds the temporal framework denoting the end of the Late Old Women's phase and the start of the Mortlach phase in south-central Saskatchewan and the regional variation seen in delineating the eastern edge of the Late Old Women's phase, it is difficult to definitively assign the occupation at EkNk-3 to one phase or the other. The artifact assemblage at this site, while very small, contains a broader array of locally sourced lithic materials than the assemblages observed at EkNj-4 and EkNj-68 which date approximately 200 years later. While not conclusive, this could suggest a Late Old Women's phase occupation at this site with a reliance on locally available lithics. In spite of neither ceramics nor diagnostic artifacts being recovered from EkNk-3, the success of the magnetometry program in locating a datable hearth and the limited excavations which were carried out have resulted in the identification of a site which could prove very useful for investigating this period of transition.

7.4 Spatial Arrangements

As was described in Chapter 6, spatial analysis was conducted for domestic and ceremonial sites located at the western end of Little Manitou Lake. For domestic sites EkNj-4, EkNj-68, and EkNk-3, spatial analyses involved nearest neighbor analysis, proximity analysis, and viewshed analysis. For ceremonial sites, individual and cumulative viewshed analyses were carried out. The results from these analyses are discussed below.

7.4.1 Domestic Sites

Spatial analyses, such as nearest neighbor analysis, have been successfully used to examine patterning of features within stone circle sites to aid in characterizing site structure and in some cases contemporaneity (*cf.*, Billeck 1983; Damkjar 2003; Long 2011). However, while nearest neighbor has been conducted with some success for some stone circle sites (e.g., Damkjar 2003), given the problems that can arise from inflated site area due to outlying features (Conolly and Lake 2006), results of the analysis need to be carefully evaluated when assessing patterning at stone circle sites. Such assessment is further complicated at larger sites where reoccupation over time may have occurred, making it difficult to discern single occupation events or defined site boundaries containing contemporaneous features. In addition, while sites of more than five rings often reflect repeatedly occupied localities, they may also represent more complex social gatherings where larger numbers of household units gathered (Dooley 2002; Oetelaar 2003). Although the method has some drawbacks, it does allow a researcher to evaluate spatial distribution of stone circles quantitatively and assists in the detection and characterization of patterning at a given site, identifying the patterning as either clustered, random, or dispersed/regular.

In an effort to determine the type of stone circle patterning present at EkNj-4, EkNj-68, and EkNk-3, nearest neighbor analysis was employed. Because all sites had apparent outlying features which have the potential to skew results, two sets of nearest neighbor analyses (one with all features and one eliminating outlying features) were carried out in an effort to understand patterning at these sites.

Initial results for EkNj-4 and EkNj-68 suggested a random distribution of ring features. Random ring distribution is thought to reflect either multiple occupations (Billeck 1983) and/or

large cluster camps which historically contained an irregular arrangement of lodges (Banks and Snortland 1995). This type of camp has been observed elsewhere in Saskatchewan and Alberta (e.g., DkMr-33 [Young and Markowski 2009] and DIPb-13 [Damkjar 2003]). Because EkNj-4 and EkNj-68 contain a large number of rings (EkNj-4 = 41 rings and EkNj-68 = 15 rings), they could fall into this category. Banks and Snortland (1995:130) define a *cluster camp* as "an irregular arrangement of tipis clustered in groups. These camps are larger than group camps, and the clustering suggests aggregation. The mean number of tents observed was 27.3...and range [from] seven to 100 [lodges]". Oetelaar (2003) goes on to suggest that this camp type is:

often arranged in smaller groups of three to seven tipis. Although the plan of the encampment appears to be an informal assemblage of lodges, the location of individual tipis is actually determined by kinship and physiography. Unlike the formal camp circle then, the cluster camp appears to be a rather informal gathering of small social units, each of which consist of kin groups [2003:119].

These smaller groupings of rings within a large site are present at both EkNj-4 and EkNj-68 (see discussion of proximity analysis below).

Conversely, the initial results from the nearest neighbor analysis for EkNk-3 suggest that the distribution of ring features are dispersed/regular. Billeck (1983) has suggested that the more regular/uniform the distribution of stone circles, the more likely the features reflect a single occupation, and therefore possibly a group camp. This fits with Banks and Snortland's (1995) description of group camps which they describe as ranging from one to 29 tents comprised of interrelated groups (extended families) and/or are associated with specialized activities.

To verify that suspected outlying features at these sites were not skewing the nearest neighbor analyses, the model was recalculated with outlying features eliminated. Results for EkNj-4 and EkNk-3 did not change, suggesting that the results of the nearest neighbor analyses accurately reflect feature distribution at these sites. However, recalculated results for EkNj-68 suggest that the core area of the site reflects a dispersed/regular distribution of features, perhaps indicative of a single occupation of interrelated people (Banks and Snortland 1995; Billeck 1983).

Proximity analysis was also carried out to expand upon and illustrate patterning not detected by the nearest neighbor analysis. All sites demonstrated areas of linear feature arrangements and small clusters of features (as noted above). Linear camps have been suggested to be a Late Precontact/Protocontact phenomenon, a supposition which is supported by the dates

obtained from all three sites (Banks and Snortland 1995; Damkjar 2003). Banks and Snortland (1995:139) also suggest that linear camps may relate to ceremonial activities, therefore it is possible that these camps are associated with the ceremonial sites located around the western end of Little Manitou Lake. The small clusters of features are presumed to represent family unit groups. Damkjar (2003) notes that small clusters of two to five rings are likely to be contemporaneous occupations by just a few families, likely during the summer or fall. However, they could also represent instances of repeated use with features from different use events being placed close to each other. Without further testing at these features it is difficult to say how features in small clusters relate.

Results of the viewshed analysis revealed that Little Manitou Lake did not play a significant role in the viewscape for EkNj-4 and EkNj-68. From a geographical perspective, the terraces on which EkNj-4 and EkNj-68 sit impede the views of the lake from these sites. However, both sites have expansive views around them despite the inability to see the lake. Dooley (2002) has postulated that visibility played a significant role in the reuse of places across the landscape and that places which exhibit high visibility often demonstrate the highest degrees of reuse. He goes on to suggest that places with high visibility may demonstrate more complex place-use histories than places with lower visibility, although he is careful to note that this was not the only factor in determining the degree to which a place is reused. Factors such as resource allocation, belief systems, and individual perceptions may also have influenced the attractiveness of certain places.

The results of the viewshed analysis for EkNk-3 revealed the Little Manitou Lake played a significant role in its viewscape. If game birds were a resource sought by site occupants, then visibility of the lake would have been an important factor in site placement as the western end of Little Manitou Lake is an important staging location for migrating species (as noted in Sections 2.3.1 and 7.3.2). As well, while access to potable water was likely a significant factor in choosing site placement throughout Northern Plains occupations, it is interesting to note that a commonality of many Late Old Women's phase sites is access to nearby sources of fresh running water (Walde et al. 1995). While Little Manitou Lake was not a freshwater lake during the dated occupation of EkNk-3, the site sits between two freshwater streams within 100 m of site features to the north and south which drain into the lake, perhaps a deciding factor for site placement by the occupants of this locale.

7.4.2 Ceremonial Sites

Viewshed analysis of the ceremonial sites located at the western end of Little Manitou Lake revealed that all sites were inter-visible with at least two other ceremonial sites. In addition, and perhaps most interesting, are the viewshed results for EkNk-4 (see Figure 6.2-1). Despite having the smallest field-of-view of all the ceremonial sites in the area, it is visible from six of the seven other ceremonial sites. The site contains the largest glacial erratic in the southern half of the province, known as the *Grandfather Rock* by local First Nations, and has been suggested to be of ceremonial significance (Cyr-Steenkamp et al. 2010; McDougall 2000). The viewshed results suggest that the location played a prominent role as a focal point within the precontact cultural landscape.

Researchers have demonstrated the power that prominent rocks can hold within archaeological landscapes (e.g., Hanna and Gibson 1993; Irwin 1994; Tilley 1996) and it seems likely that the same may be true for the glacial erratic at EkNk-4. Such rocks have also served as gathering places between peoples. Stories have been documented about the importance of the *Mistaseni Rock* (EgNo-19 - see Figure 7.3-1 - inset) located in the Qu'Appelle River valley, as an important and sacred meeting place for the Plains Cree and Assiniboine (Christensen 2000; Lang 2010). The rock, a 400-tonne glacial erratic (the largest in Saskatchewan; the remains of which lay under Lake Diefenbaker following the damming of the South Saskatchewan River in the 1960s) was believed to be the spirit of Manitou (the great spirit) and was the centre of a complex ceremonial site (Christensen 2000; Lang 2010; Pohorecky 1959). Like the importance of the meeting place at the *Mistaseni Rock*, it is possible that the large glacial erratic at EkNk-4 also held a place of import as a gathering place.

7.5 Paleoenvironmental Record

As discussed above, the radiocarbon dates obtained from the archaeological sites considered in this study place site occupation between the late AD 1400s and 1600s (see Chapter 5 and Section 7.2). As such, an overview of paleoenvironmental changes which occurred during this period is warranted to better understand conditions residents at these sites would have experienced.

Following the Medieval Warm Period, which has been postulated to have occurred between approximately AD 1100 and 1250 (Edwards et al. 2008), conditions on the Northern Plains are thought to have become cooler, defined as the Little Ice Age which persisted on the Canadian prairies between approximately AD 1450 to 1850 according to Lemmen and Vance (1998) or AD 1530 to 1890 according to Edwards et al. (2008). The cooling attributed to this period is believed to have contributed to the southward diffusion of Arctic air masses in many parts of the Northern Hemisphere (Kreutz et al. 1997). Edwards et al. (2008:193-194) have postulated that this period was characterized by generally cool winters and dry growing seasons in association with known glacial advances. Hart (2009:60) further suggests "that although the overall period was generally cold and dry there were variations in both temperature and precipitation resulting in periods that were warmer and moister." Indeed, this period has been divided into three phases which reflect the variation the Little Ice Age experienced: an initial cold phase, a warmer phase, and a very cold phase (Hart 2009; St. Jacques et al. 2008).

Unfortunately, most paleoenvironmental studies carried out on the Northern Plains lack the resolution required to hone in on variations in broader climatic trends, such as those noted above for the Little Ice Age. Sauchyn and Beaudoin (1998) note that most coarse-scale data, such as that derived from lake sediment studies, typically only provide an indication of gross-scale changes (e.g., Medieval Warm Period, Little Ice Age); higher-resolution data, such as tree-ring records or detailed fossil pollen analyses, are required to demonstrate greater complexity during these broad trends. This is true for lake sediment data reviewed in Chapter 2 for Humbolt, Deadmoose, Redberry, and Waldsea lakes (Figure 7.5-1) which all point to a cooling trend in the region during the Little Ice Age but lack the resolution required to pick up on subtler local variations during this period. This is also true for the paleolimnological data reviewed for Little Manitou Lake, with the exception of an increase in sodium precipitates for a short interval during the most recent lithostratigraphic deposits (Facies A) which could relate to a decrease in solubility of Na-sulfates as a result of the coolest phase of the Little Ice Age.

While there is a paucity of high-resolution paleoenvironmental data for the region around Little Manitou Lake, some inferences can be made using high-resolution data from a lake on the northern edge of the Great Plains in central Saskatchewan: North Flat Lake, located 218 km north of Little Manitou Lake in the Prince Albert Provincial Park (Figure 7.5-1; Hart 2009). Although North Flat Lake is over 200 km north of Little Manitou Lake and within the Boreal

Forest-Aspen Parkland ecotone, or transition zone, it provides some indications of the variation which the Little Manitou Lake region may have experienced during the Little Ice Age. Data from this lake were compared with those obtained from Humboldt Lake (approximately 53 km northeast of Little Manitou Lake, used as a local comparative lake in Chapter 2 - see Section 2.2.2) which showed generally favourable correlations in observed paleoclimatic conditions throughout the lake cores (Hart 2009; Laird et al. 2003). Therefore, the high-resolution record in North Flat Lake is considered an appropriate dataset to infer possible paleoenvironmental

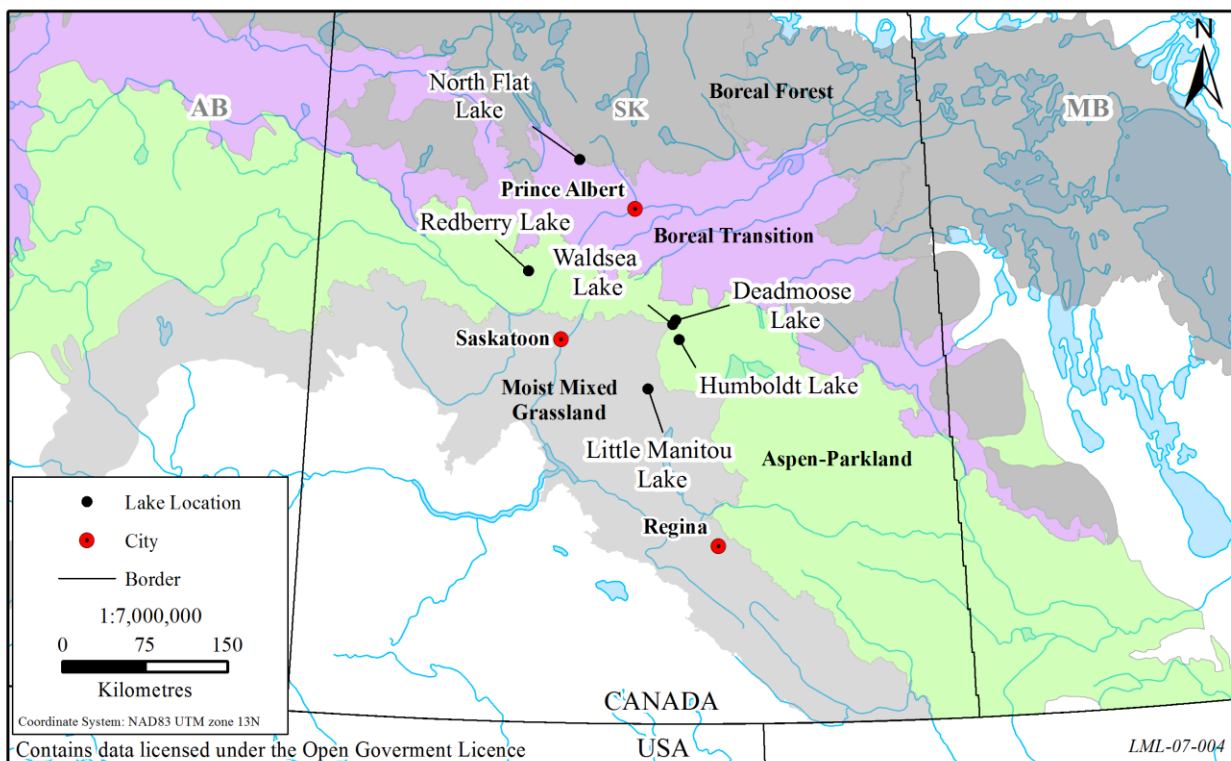


Figure 7.5-1. Lakes on the Northern Plains discussed in this chapter.

changes which may have occurred in the Little Manitou Lake region during the Little Ice Age. In addition, St. Jacques et al. (2008) note that high-resolution pollen analysis, such as that collected at North Flat Lake, is useful in conjunction with paleolimnological methods, such as those from Little Manitou Lake, because they have the potential to distinguish between colder versus wetter and warmer versus drier periods. Limnological moisture proxies may also be complicated by unknown groundwater inputs which is likely true for Little Manitou Lake.

The initial cooling phase of the Little Ice Age has been documented in North Flat Lake from AD 1400-1500 as a steep decline in annual temperature following the Medieval Warm Period (Hart 2009). This time period correlates with the site occupation of EkNk-3 (AD 1472;

326 ± 34 yr BP), the site situated at the western end of Little Manitou Lake. It is possible that the lake levels during this period of occupation were low, due to the warmer conditions of the preceding period but may have been on the rise due to decreases in evaporation as a result of cooler temperatures (Ward and Robinson 2000) and influxes of groundwater.

This initial cooling phase was followed by a warmer phase between AD 1500-1600 at North Flat Lake (Hart 2009). While none of the radiocarbon dates from sites investigated during this study correlate with this phase it provides some new paleoenvironmental data to consider during a time when water levels and salinity may have been in flux in the Little Manitou Lake basin.

The coldest phase of the Little Ice Age occurred between AD 1600-1750 at North Flat Lake (Hart 2009). These dates correlate with the site occupation of EkNj-4 (AD 1667; 158 ±20 and 160 ±19 yrs BP) and EkNj-68 (AD 1681; 121 ±22 yr BP). It is likely that the occupants of these sites experienced cooler and possibly moister conditions than those of the earlier part of the Little Ice Age or conditions which persist today. In addition, it is possible that the sodium levels in the lake were reduced due to the precipitation of Na-sulfates out of the water column as a result of cooler temperatures.

Interestingly, charcoal from both *Populus/Salix* and *Alnus* sp. were recovered from EkNj-4. These species can become established within or adjacent to the Aspen-Parkland with sufficient moisture and if fires are not too frequent (Bird 1961). During his exploration of Saskatchewan, Hind (1859:52) noted that "if a portion of prairie escapes fire for two or three years the result is seen in the growth of willows and aspen...". It is possible that cooling and perhaps moister conditions during the latter part of the Little Ice Age would have been favourable for the establishment of these deciduous species within the region.

Although it was hoped that the paleolimnological record of Little Manitou Lake might provide paleoenvironmental information for the region that could be compared to site-specific information from the archaeological sites considered in this study, the resolution was simply not high enough to glean information about the environmental variation that people occupying the sites would have had to respond to during the Little Ice Age. Despite this, comparable data from other lakes in the province have helped shed light on environmental variation which likely occurred at Little Manitou Lake and the conditions which people would have experienced. It is interesting that the instances of occupation at all three sites fall during periods of increased

cooling. While much more research would be required at other sites around Little Manitou Lake to explore the temporal framework of occupation in the area and the associated environmental conditions, at present it seems that the cooler conditions which persisted during the Little Ice Age did not negate use of this area but perhaps may have influenced its use.

Chapter 8

Conclusions and Future Research Directions

8.1 Concluding Remarks

The objective of this thesis centered around improving understanding of interactions between past human populations and the environment of the Little Manitou Lake area and to set the local archaeological record into the broader context of Northern Plains prehistory. Although nearly 100 archaeological sites have been documented within the study area, few have produced artifacts and none (other than those investigated for this study) have been dated by radiometrics to provide insight about the temporal framework for the area or the cultural groups who once occupied the sites. The Little Manitou Lake archaeological complex offered a rare opportunity to evaluate a large group of stone circle sites which have remained largely undisturbed for centuries, save some cattle and light vehicle disturbance. Data obtained from these sites has added to the archaeological record for this region and provided a better understanding of the environment people may have experienced.

To achieve the objective of this study, three goals were identified and explored. Hearth deposits were identified containing charred organics which produced dates for all three sites, establishing part of the cultural chronology for the region and provided data which suggest occupation occurred during the late summer or early autumn. Dates from these sites also enabled the assessment of whether occupation occurred when either fresh or saline water conditions persisted in Lake Manitou Lake. Literature pertaining to paleoenvironmental changes which occurred in the Little Manitou Lake region was reviewed to determine if Little Manitou Lake was a saline lake during site occupation and to better understand the environment which site residents may have experienced. Spatial evaluations of domestic sites at the western end of Little Manitou Lake provided insight about patterning of features at the sites. Spatial evaluations of ceremonial sites provide insight about the importance of topographic features and helped to

elucidate the overall cultural landscape. Taken as a whole, data collected during this study provides substantive new insights about the archaeological environment at Little Manitou Lake.

Radiocarbon dates from EkNj-4 and EkNj-68 and the positioning of these sites in south-central Saskatchewan suggest occupation occurred during the Mortlach phase. In spite of the inability to securely assign these sites to a particular Mortlach subphase, due to the paucity of recovered artifacts/ceramics, comparisons with other sites in the region suggest that the Lozinsky subphase may have persisted in the area around Little Manitou Lake since Lozinsky subphase type ceramics have been recovered from sites located within 15 to 30 km to the northeast and east of the western end of Little Manitou Lake (*i.e.*, ElNi-1, ElNi-2, EjNg-3, and EkNg-29). These regional sites contain no Lake Midden subphase ceramics, despite the Lake Midden key-site (EfNg-1) being located only 80 km to the south-southeast. Site placement near the parkland-grassland interface also helps to reinforce the supposition that the Little Manitou Lake sites may relate to the Lozinsky subphase.

Conversely, radiocarbon dates from EkNk-3 suggest occupation occurred during a period of transition from the Late Old Women's phase to the Mortlach phase in this part of Saskatchewan. Comparisons with sites in the immediate vicinity (*i.e.*, ElNi-1, ElNi-2, EjNg-3, and EkNj-29) demonstrate that Old Women's phase was present in the area, however, these comparisons have not been able to expand further our understanding of whether the early or late expressions of the Old Women's phase occupations occurred in the region. Given the paucity of artifacts/ceramics from the limited excavations carried out at EkNk-3, there remains some uncertainty whether this site relates to the Late Old Women's phase or early Mortlach phase. Further investigations at this site could prove useful for investigating this period of transition and expand on this line of inquiry.

Based on the radiocarbon dates from these sites and an evaluation of paleoenvironmental data from the region, occupation fell during the Little Ice Age when conditions were generally cooler and drier than the period preceding it or modern conditions. EkNk-3 was occupied during the earliest part of the Little Ice Age when a steep decline in annual temperature was being experienced across the Northern Plains following the Medieval Warm Period. It is possible that lake levels were low during this period of occupation, due to the drier conditions which preceded this period. EkNj-4 and EkNj-68 were occupied during the terminal phase and coldest part of the

Little Ice Age when conditions were cooler and possibly moister than today or than those experienced at the beginning of the Little Ice Age.

This was also a period of time when Little Manitou Lake was hypersaline. However, because of the cooler conditions which persisted during the Little Ice Age, it is possible that sodium-sulfates in the lake precipitated out of the water column due to reduced solubility at lower temperatures, possibly reducing the salinity of the lake for this period of time. One might expect that the cooler conditions of this period influenced the selection of site locations across the Northern Plains. It seems that the Little Manitou Lake region was favourable during this period, drawing occupants to the area.

Spatial analysis of these three sites provided some insight into patterning and possible clusters of stone circle features. Nearest neighbor analysis was employed as one line of inquiry for the spatial analysis of features at these sites. Although nearest neighbor analysis may not be a perfect tool for analyzing stone circles sites, due to problems that can arise from inflated site areas as a result of outlying features skewing the characterization of feature distribution, it does provide some interesting food for thought that is relevant in understanding patterning at stone circle sites. Knowing that this may be a shortcoming of the tool, researchers can evaluate a site as a whole and if necessary eliminate outlying features to determine if different characterization of feature distribution is detected.

Because outlying features were suspected at all three sites, particularly at EkNj-4, two sets of nearest neighbor analyses were carried out in an effort to better understand patterning of stone circles at these sites. Initial results, considering all stone circle features, pointed to a random distribution of features at EkNj-4 and EkNj-68, which might reflect multiple occupations but may also be indicative of large cluster camps which form as irregular arrangements of lodges during periods of aggregation. Conversely, nearest neighbor results pointed to a dispersed/regular distribution of features at EkNk-3 which may reflect a single group occupation, possibility of interrelated family units and/or a gathering associated with a specialized activity.

Following this initial modeling, the nearest neighbor analyses were recalculated, this time eliminating suspected outlying features from the models. Interestingly, results for EkNj-4 and EkNk-3 did not change, suggesting that the results of the nearest neighbor analyses accurately reflect feature distribution at these sites. However, recalculated results for EkNj-68 suggest that the core area of the site reflects dispersed/regular distribution of features, perhaps indicative of a

single occupation event and/or an occupation of interrelated people. Outlying features at this site may be evidence of a different occupation event and/or represent isolated/specialized structures placed away from the main camp area.

Proximity analyses was also carried out to aid in reviewing possible patterning and proximity between rings not detected in the nearest neighbor analyses. These results further revealed that all sites contained linear arrangements of features, as well as small groupings. Linear arrangements of features have been postulated to be indicative of Late Precontact/Protocontact occupations, which is supported by the dates from all three sites. In addition, such linear arrangements have also been suggested to related to ceremonial activities. Small clusters of features within larger sites have been suggested to represent family unit groupings.

While it is difficult to say if visibility of Little Manitou Lake influenced the selection and placement of domestic sites on this landscape, viewshed analysis revealed that Little Manitou Lake did not play a significant role in the viewscape for EkNj-4 and EkNj-68 although both sites had expansive fields-of-view which simply did not take in the lake. Conversely, Little Manitou Lake played a significant role in the viewscape of EkNk-3, accounting for a large proportion of its field-of-view and may have been an important factor for site residents when choosing this location.

Viewshed analysis of ceremonial sites at the western end of Little Manitou Lake provided some interesting results which may reflect the perceptions of the past occupants of this cultural landscape and provide some insight into why the area was so intensively used. Viewshed results suggest that site inter-visibility between ceremonial sites may have played a critical role in site placement. In particular, the glacial erratic at EkNk-4, despite having the smallest fields-of-view of all other ceremonial site in the area, is visible from six of the seven other ceremonial sites. The visual dominance of this site seems to demonstrate that the site/erratic may have played a prominent role as a focal point within the precontact landscape and may have influenced where other ceremonial sites were placed. Whether the glacial erratic served as an important landscape symbol remains unknown, however, it is possible that it played a function in drawing people to this place.

8.2 Areas For Future Research

While the objective and goals set out for this research have been satisfied, results of this study have identified several lines of inquiry that would benefit from further research.

Since the research design for this study targeted very small areas at three sites within the Little Manitou Lake archaeological complex, with a goal to identify hearths by which to date the sites, the temporal and cultural data provided in this thesis are limited to snapshots of occupations. Additional testing at these sites and others adjacent to Little Manitou Lake would help to verify and reinforce the findings of this study and add to understanding of when and how the region was used prehistorically.

A primary goal of this research was successfully met through the use of magnetometry to target areas for excavation which resulted in the identification of three datable hearths at three sites in a short period of time. The results of the magnetometry surveys also identified many other targets at these sites which are presented in Appendix A. Additional subsurface testing at these sites could provide additional dating evidence which would help verify cultural associations of the sites as well as determine if they represent single occupation events or if they saw multiple occupations through time.

The use of magnetometry also minimized damage to the sites by greatly reducing the area which was subject to subsurface investigations (less than 2 m² was excavated at each site) to meet a goal of the research, which was to date the sites. Where suitable conditions exist (*i.e.*, areas which exhibit limited surficial rock), the use of magnetometry at stone circle sites is recommended, particularly if the goal of the research, at least in part, is to obtain chronometric dates for site occupation. Use of magnetometry can also help to locate features and activity areas outside of stone circle features that may not be recognized by surface inspection, thereby identifying targets for excavation within communal areas of the sites which may only be fortuitously discovered by standard testing procedures. This could be of particular value for sites which were occupied during warmer periods of the year when central hearths would be less likely to have been used.

The use of a hand-held magnetic susceptibility instrument (such as the TerraPlus KT-10 susceptibility instrument which was employed to evaluate soil post-excavation) would likely have allowed for more precise delimitation of the hearths, particularly for the hearth encountered

at EkNj-68 which was not well defined. In addition, given the dark nature of the soil in this region of the province, the differentiation between natural soil deposits and charcoal stained soil can be difficult. Having an instrument which can take active readings to identify soil with elevated magnetic characteristics (often a result of firing) during excavation would be helpful in this regard.

The successful application of the magnetometry surveys and limited excavation resulted in the discovery of a site (EkNk-3) which dates to the terminal Late Precontact period during a transitional time between the Late Old Women's and early Mortlach phases. Further research at this site could prove very useful for investigating the transition between these two phases in this part of the province. In addition, further research at EkNj-4 and EkNj-68 could prove helpful in exploring the geographic range and/or interactions between the northern and southern expressions of the Mortlach subphases. Because excavations at these sites were limited to areas less than 2 m², the majority of subsurface deposits at these sites remain intact for future research.

Additional subsurface investigations with a goal to date more of the sites could provide insight into when the area became important for ceremonial and domestic use. If all sites around Little Manitou Lake post-date approximately 2,000 years BP, one might conclude that the saline nature of the lake was a factor drawing people to the area.

For some of the larger stone circles sites (those exceeding 5 stone circles), investigations exploring contemporaneity would be of value to determine if sites were being reoccupied year after year and to shed light on a more comprehensive temporal scale of occupation. Spatial analyses on other sites in the Little Manitou Lake area and across the Northern Plains, such as the nearest neighbor and proximity analyses which were explored for this study, may also aid in this regard.

Although the POSL results from EkNk-3 proved difficult to reconcile with other data recovered from the site, they did provide some insight regarding depositional history. Further comparisons of POSL data with traditionally excavated data from stone circles sites could provide fruitful in helping to understand depositional histories and identifying multiple occupations which are often compressed and difficult to discern. Standard OSL samples which can provide chronometric data could also prove useful when organics and diagnostics are absent.

Documentation of other attribute data for stone circle sites in the study area, as well as sites across Saskatchewan, would provide a more comprehensive dataset for analyzing and

comparing sites. Such attribute data could include ring gaps (particularly for previously documented features at EkNj-4 and EkNk-3), number of wall courses, and octant ring counts. This could assist in both comparisons with other sites across the province as well as evaluating viewsheds from doorway openings and postulating directionality of wind.

Further exploration of the relationship between ceremonial and domestic sites could add to our overall understanding of this social landscape. Such an exploration could involve a more detailed evaluation of the spatial relations between these site types. In addition, an evaluation of other ceremonial sites found in the region could provide a broader understanding of the cultural landscape and elucidate the relationship between ceremonial sites and complexes on a regional basis.

Should additional data become available for paleoenvironmental changes for Little Manitou Lake, or the region, further evaluation could be carried out to better understand how such changes may have influenced occupation and use of the area. Finer resolution of paleoenvironmental data would be most helpful in comparing archaeological occupation to changes in the environment.

8.3 Summary

In summary, this research adds to our understanding of the archaeological environment of the Little Manitou Lake area and builds on the solid foundations of stone circle research laid down by many previous investigators across Saskatchewan and the Northern Plains. While the current research was limited to investigations at only a handful of sites within the Little Manitou Lake archaeological complex and only scratches the surface of the data enclosed therein, it provides a glimpse of when the sites were in use, the activities that were taking place, and the environment in which the occupants lived. Doubtless, generations of people visited the area year after year, leaving behind evidence of their time spent at the lake. As with most research, the need for future investigations in this region is evident; it is my sincere hope that further investigations will continue to shed light on this area which was clearly an important gathering place in the past.

References Cited

- 1944 *Flood Control Act of 1944*, ch. 665, 58, Stat. 887. Bureau of Reclamation, United States of America.
- 1966 *National Historic Preservation Act of 1966*, Pubic Law 89-665; 16 U.S.C. 470 *et seq.* National Parks Service, United States of America.
- 1980 *Heritage Property Act*, Chapter H-2.2. Statutes of Saskatchewan.
- 1992 *Wildlife Habitat Protection Act*, c.66, s.4. Statutes of Saskatchewan.
- 2000 *Historical Resources Act*, Chapter H-9. Statutes of Alberta.
- Aaberg, Stephen A., William P. Eckerle and Kenneth P. Cannon
2003 Cree Crossing (24PH3396): The Cultural and Paleoenvironmental Record. *Archaeology of Montana* 44(1):1-72.
- Acton, D.F., G.A. Padbury and C.T. Stushnoff
1998 *Ecoregions of Saskatchewan*. Canadian Plains Research Center, University of Regina, Regina.
- Adams, Gary
1978 *Tipi Rings in Southern Alberta: the Alkali Creek Sites, Lower Red Deer River* Occasional Paper No. 9. Archaeological Survey of Alberta, Edmonton.
- 1983 Tipi Rings at York Factory: An Archaeological-Ethnographic Interface. In *From Microcosm to Macrocosm: Advances in Tipi Ring Investigations and Intrerpretation*, edited by L. B. Davis, pp. 6-15. *Plains Anthropologist* 28(102) Pt. 2, Memoir 19.
- Ainsworth, S. and B. Thomason
2003 *Where on Earth are We? The Global Positioning System (GPS) in Archaeological Field Survey*. English Heritage, Swindon.
- Allaby, Michael
2008 *Oxford Dictionary of Earth Sciences*. 3rd ed. Oxford Refernces, Oxford.
- 2010 *Oxford Dictionary of Ecology*. 4th ed. Oxford University Press, Oxford.
- Amundson, Leslie
1986 *The Amisk Site: A Multicomponent Campsite in South Central Saskatchewan*. Unpublished M.A. thesis, Department of Archaeology, University of Saskatchewan, Saskatoon.

- Anderson, Richard C.
2001 Kite Aerial Photography for Archaeology: An Assessment and Short Guide. *British School at Athens Studies* 8:167-180.
- Anderson, T.W., R.W. Mathewes and C.E. Schweger
1989 Holocene Climatic Trends in Canada with Special Reference to the Hypsithermal Interval. In *Quaternary Geology of Canada and Greenland*, edited by R. J. Fulton, pp. 520-528. Geological Survey of Canada Geology of Canada No. 1, Geological Survey of Canada, Ottawa.
- Andrefsky, William
2005 *Lithics: Macroscopic Approaches to Analysis*. 2nd ed. Cambridge University Press, Cambridge.
- Antevs, Ernst
1955 Geologic-Climatic Dating in the West. *American Antiquity* 20(4):317-335.
- Archaeological Resource Management Section
2013 *Guide to the Interactive Saskatchewan Archaeological Resource Record*. Heritage Conservation Branch, Saskatchewan Parks, Culture and Sport, Regina, SK.
- Archeo-Physics
2012 *Case Study - Songbird Rings, Big Horn County, Montana*.
<http://www.archaeophysics.com/songbird/>, accessed March 23, 2016.
- Backhouse, Paul N. and Eileen Johnson
2007 Where Were the Hearths: an Experimental Investigation of the Archaeological Signature of Prehistoric Fire Technology in the Alluvial Gravels of the Southern Plains. *Journal of Archaeological Science* 34(9):1367-1378.
- Baldwin, Stuart J.
1995 Some Preliminary Results from a Study on Living Space in Stone Rings. *Archaeology of Montana* 36(2):45-61.
- Banks, Kimball M. and J. Signe Snortland
1995 Every Picture Tells a Story: Historic Images, Tipi Camps, and Archaeology. *Plains Anthropologist* 40(152):125-144.
- Barnes, Frank C.
2000 *Cartridges of the World*. 9th ed. Krause Publications, Iola, WI.
- Barnosky, C.W., E.C. Grimm and H.E. Wright, Jr.
1987 Towards a Postglacial History of the Northern Great Plains: A Review of the Paleoecologic Problems. *Annals of the Carnegie Museum* 56:259-273.
- Bateman, M.D., S. Stein, R.A. Ashurst and K. Sleby
2015 Instant Luminescence Chronologies? High Resolution Luminescence Profiles Using a Portable Luminescence Reader. *Quaternary Geochronology* 30:141-146.

- Beal, William James
1898 *Seed Dispersal*. Ginn and Company, Boston.
- Beaudoin, Alwynne B.
1993 A Compendium and Evaluation of Postglacial Pollen Records in Alberta. *Canadian Journal of Archaeology* 17:92-112.
- Benedict, James B.
2009 A Review of Lichenometric Dating and Its Applications to Archaeology. *American Antiquity* 74(1):143-172.
- Benn, D. W.
1974 Seed Analysis and Its Implications for an Initial Middle Missouri Site in South Dakota. *Plains Anthropologist* 19(64):55-72.
- Bevan, B and T. Smekalova
2013 Magnetic Exploration of Archaeological Sites. In *Good Practice in Archaeological Diagnostics: Non-Invasive Survey of Complex Archaeological Sites*, edited by C. Corsi, B. Slapšak and F. Vermeulen, pp. 133-152. Springer International Publishing, Switzerland.
- Billeck, William T.
1983 *Stone Ring Contemporaneity: Evaluation of Two Sites by Ring Distribution, Artifact Density Patterning, and Other Methods*. Paper presented at the 1983 Plains Conference, Rapid City, South Dakota. On file at the State Historic Preservation Office, North Dakota.
- Binford, Lewis R.
1962 Archaeology as Anthropology. *American Antiquity* 28(2):217-225.

1983 *In Pursuit of the Past: Decoding the Archaeological Record*. Thames and Hudson, London.
- Bird, Ralph D.
1961 *Ecology of the Aspen Parkland of Western Canada in Relation to Land Use*. Contribution No. 27. Research Branch, Canada Department of Agriculture, Ottawa.
- Bird Studies Canada
2010 *Canadian Bird Conservation Regions: Prairie Potholes (11)*. Environment Canada. <http://www.bsc-eoc.org/international/bcrcanada.html>, accessed April 12, 2015.
- Birkeland, Peter W.
1999 *Soils and Geomorphology*. 3rd ed. Oxford University Press, New York.
- Bishop, P., David C. W. Sanderson and M.T. Stark
2004 OSL and Radiocarbon Dating of a Pre-Angkorian Canal in the Mekong Delta, Southern Cambodia. *Journal of Archaeological Science* 31:319-336.

- Blankinship, J.W.
1905 *Native Economic Plants of Montana*. Montana Agricultural College Experimental Station, Bulletin No. 56, Bozeman, Montana.
- Bliss, Wesley L.
1949 Archaeological Reconnaissance in Wyoming and Montana, 1946-1947. *Proceedings of the Proceedings of the Fifth Plains Conference for Archaeology, Notebook 1:7-12*.
- Bowman, Sheridan
1990 *Radiocarbon Dating*. University of California Press, Berkeley.
- Brace, Geoffrey Ian
2005 *Boulder Monuments of Saskatchewan*. Saskatchewan Archaeological Society, Saskatoon.
- Brierley, J. A., H. B. Stonehouse and A. R. Mermut
2011 Vertisolic Soils of Canada: Genesis, Distribution, and Classification. *Canadian Journal of Soil Science* 91(5):903-916.
- Brink, Jack W.
2008 *Imagining Head-Smashed-In: Aboriginal Buffalo Hunting on the Northern Plains*. AU Press, Edmonton.
- Brink, Jack W. and Bob Dawe
2003 Hot Rocks as Scarce Resources: The Use, Re-Use and Abandonment of Heating Stones at Head-Smashed-In Buffalo Jump. *Plains Anthropologist* 48(186):85-104.
- Brumley, John H.
1988 *Medicine Wheels on the Northern Plains: A Summary and Appraisal*. Occasional Paper No. 12. Archaeological Survey of Alberta, Edmonton.
- Brumley, John H. and Barry J. Dau
1988 *Historical Resource Investigations Within the Forty Mile Coulee Reservoir* Manuscript Series No. 13. Archaeological Survey of Alberta Edmonton.
- Buchner, Anthony P.
1981 The Oxbow Complex and the Anomalous Winter Hypothesis. *Canadian Journal of Archaeology* (5):137-144.
- Budd, Archibald C. and Keith F. Best
1969 *Wild Plants of the Canadian Prairies*. Queen's Printer, Ottawa.
- Budd, Archibald C., Keith F. Best and J. Looman
1987 *Budd's Flora of the Canadian Prairies Provinces*. Government of Canada Research Branch, Agriculture Canada, Hull.

- Burley, David V.
1990 Tipi Rings and Alberta Prehistory: Toward a Historical and Critical Review of a Legislated Archaeology. *Plains Anthropologist* 35(132):343-357.
- Byrne, W.J.
1973 *The Archaeology and Prehistory of Southern Alberta as Reflected by Ceramics*. Mercury Series: Canadian Ethnology Series Paper No. 14. National Museums of Canada, Ottawa.
- Calder, James M.
1977 *The Majorville Cairn and Medicine Wheel Site, Alberta*. Mercury Series No. 62. Archaeological Survey of Canada, Ottawa.
- Campbell, I. D., William Last, Celina Campbell, Stephen Clare and John McAndrews
2000 The Late Holocene Paleohydrology of Pine Lake, Alberta: A Multiproxy Investigation. *Journal of Paleolimnology* 24(4):427-441.
- Campbell, Walter Stanley
1927 The Tipis of the Crow Indians. *American Anthropologist* 29(1):87-104.
- Canadian Archaeological Radiocarbon Database (CARD 2.1)
2016 *Geospatial Radiocarbon Data. Electronic Database*.
<http://www.canadianarchaeology.ca>, accessed April 28, 2016.
- Canarache, Ana, Irina Vintilă and Ioan Munteanu
2006 *Elsevier's Dictionary of Soil Science: in English (with definitions), French, German and Spanish*. Elsevier, Amsterdam.
- Carlson, Muriel
1993 Wanuskewin Chosen as Repository for First Member's Collection. *Saskatchewan Archaeological Society Newsletter* 14(1):4-5.
- Christensen, Deanna
2000 *Ahtahkakoop: The Epic Account of a Plains Cree Head Chief, His People, and Their Vision for Survival, 1816-1896*. Ahtahkakoop Publishing, Shell Lake, Saskatchewan.
- Christiansen, Earl A.
1970 *Geology and Groundwater Resources of the Wynyard Area (72P) Saskatchewan, 1970, Map No. 10*. Saskatchewan Research Council, Saskatoon.
- 1979 The Wisconsin Deglaciation of Southern Saskatchewan and Adjacent Areas. *Canadian Journal of Earth Sciences* 16(4):913-938.
- 1992 Pleistocene Stratigraphy of the Saskatoon Area, Saskatchewan, Canada: An Update. *Canadian Journal of Earth Sciences* 29(8):1767-1778.

- Clark, Philip J. and Francis C. Evans
1954 Distance to Nearest Neighbor as a Measure of Spatial Relationships in Populations. *Ecology* 35(4):445-453.
- Clarke, Arthur Haddleton
1981 *The Freshwater Molluscs of Canada*. National Museum of Natural Sciences, Ottawa.
- Conaty, Gerald T., Margaret G. Hanna and Lawrence Melit
1988 Patterns of the Past: Saskatchewan's Collection Registration Program. *Saskatchewan Archaeology* 9:15-24.
- Conolly, James and Mark Lake
2006 *Geographical Information Systems in Archaeology*. Cambridge University Press, Cambridge.
- Cvancara, Alan M
1983 *Aquatic Mollusks of North Dakota*. Report of Investigation No. 78, North Dakota Geological Survey. Kaye's Inc., Fargo, ND.
- Cyr-Steenkamp, T., M. Manchur and T. Jones
2010 *Report on Little Manitou Erratic (EkNk-4) Mapping and Additional Research Carried Out from July 20 to September 1, 2006: An Update on the Original 2006 Report Submission*. Saskatchewan Archaeological Society, Saskatoon.
- Cyr, Howard, Calla McNamee, Andrea Freeman and Leslie Amundson
2011 Reconstructing Landscape and Vegetation Through Multiple Proxy Indicators: A Geoarchaeological Examination of the St. Louis Site, Saskatchewan, Canada. *Geoarchaeology* 26(2):165-188.
- Cyr, Talina J.
2006 *The Dog Child Site (FbNp-24): A 5500 Year-Old Multicomponent Site on the Northern Plains*. Unpublished M.A. thesis, Department of Archaeology, University of Saskatchewan, Saskatoon.
- Dalan, Rinita A.
2006 Magnetic Susceptibility. In *Remote Sensing in Archaeology: an Explicitly North American Perspective*, edited by J. K. Johnson, pp. 161-203. University of Alabama Press, Tuscaloosa.
- Damkjar, Eric
2003 *Cranford East Site (DIPb-13): Stone Circles and Alignments in Southern Alberta*. Prepared for Alberta Transportation and Utilities by ERD Heritage Consulting, Edmonton. On file with the Archaeological Survey of Alberta.

Dasovich, Steve

1998 *An Analysis and Critique of Stone Circle Research in the Northern Plains: The View From South Dakota*. Unpublished Ph.D. dissertation, University of Missouri, Columbia.

Dau, Barry J.

1981 Three Methods of Rapidly Recording and Testing Archaeological Sites. In *Megaliths to Medicine Wheels: Boulder Structures in Archaeology, Proceedings of the Eleventh Annual Chacmool Conference*, edited by M. Wilson, K. L. Road and K. J. Hardy, pp. 39-46. University of Calgary Archaeological Association, Calgary.

Dau, Barry J. and John H. Brumley

1987 *Historical Resource Investigation within the Forty Mile Coulee Reservoir: Data Summaries, in 4 Parts. Permit 86-020*. Prepared for Alberta Environment. On file with the Archaeological Survey of Alberta.

Davis, Leslie B.

1983a *From Microcosm to Macrocosm: Advances in Tipi Ring Investigations and Interpretation*. Plains Anthropologist 28(102) Pt. 2, Memoir 19.

1983b Introduction to Tipi Ring Problems and Research. In *From Microcosm to Macrocosm: Advances in Tipi Ring Investigations and Interpretation*, edited by L. B. Davis, pp. 1-5. Plains Anthropologist 28(102) Pt. 2, Memoir 19.

Davis, Leslie B. and R.E. Carroll

1981 Aerial Photogrammetry of Stone Circles and Piled-stone Alignments at the Ulm Pishkun State Monument. In *Megaliths to Medicine Wheels: Boulder Structures in Archaeology, Proceedings of the Eleventh Annual Chacmool Conference*, edited by M. Wilson, K. L. Road and K. J. Hardy, pp. 9-29. University of Calgary Archaeological Association, Calgary.

Dawson, George Mercer

1875 *Report on the Geology and Resources of the Region in the Vicinity of the Forty-Ninth Parallel, from the Lake of the Woods to the Rocky Mountains: with Lists of Plants and Animals Collected, and Notes on the Fossils*. British North American Boundary Commission, New York.

Day, Edward and Jeffrey L. Eighmy

1998 The Biscuit Hill Stone Circles: 5WL1298. *Southwestern Lore* 64(3):1-21.

De Mille, G., J. R. Shouldice and H. W. Nelson

1964 Collapse Structures Related to Evaporites of the Prairie Formation, Saskatchewan. *Geological Society of America Bulletin* 75(4):307-317.

Deaver, Ken

1983 Rings at the Johnson Bison Kill Site, 24PH8. *Plains Anthropologist* 28(102):59-70.

- 1989 Identifying Ring Site Occupations. In *Households and Communities: Proceedings of the Twenty-First Annual Conference of the Archaeological Association of the University of Calgary*, edited by S. McEachern, D. J. W. Archer and R. D. Garvin, pp. 256-265. University of Calgary, Calgary.
- Deaver, Ken and Sherri Deaver
1987 *Dancing Grouse, A Tipi Ring Site in Central North Dakota*. Ethnoscience for Falkirk Mining Company, Bismark, ND.
- Deaver, Ken and J. Morter
1981 *Site Distribution in the Fresno and Nelson Reservoir Areas, North Central Montana*. Professional Analysts for US Bureau of Reclamation, Upper Missouri Region, Billings, MT.
- Deevey, E. S. and R. F. Flint
1957 Postglacial Hypsithermal Interval. *Science* 125(3240):182-184.
- Discover the Outdoors
2009 *Shotguns*. <http://www.dto.com/hunting/article/542>, accessed January 27, 2016.
- Donkin, John G.
1973 *Trooper and Redskin in the Far North-West: Recollections of Life in the North-West Mounted Police, Canada, 1884-1888*. Coles Publishing Co., Toronto.
- Dooley, Mathew A.
2002 *Assessing the Role of Visibility in Prehistoric Place Use in Central North Dakota*. Unpublished M.A. thesis, Geography, University of Nebraska, Lincoln, Nebraska.
- Drury, J., S. Ylioja and K. Green
2012 *Rehabilitating the Saskatoon South East Water Supply System*. Saskatchewan Ministry of Agriculture, Regina. http://www.agriculture.gov.sk.ca/agv1209_pg7, accessed April 12, 2015.
- Duller, G.A.T. and A.G. Wintle
2012 A Review of the Thermally Transferred Optically Stimulated Luminescence Signal from Quartz for Dating Sediments. *Quaternary Geochronology* 7:6-20.
- Dunnell, Robert C.
1982 Science, Social Science, and Common Sense: The Agonizing Dilemma of Modern Archaeology. *Journal of Anthropological Research* 38(1):1-25.
- Dyck, Ian G.
1983 The Prehistory of Southern Saskatchewan. In *Tracking Ancient Hunters: Prehistoric Archaeology in Saskatchewan*, edited by H. T. Epp and I. G. Dyck, pp. 63-139. Saskatchewan Archaeological Society, Saskatoon.
- Ebert, James I.
1992 *Distributional Archaeology*. University of New Mexico Press, Albuquerque.

- Edmunds, F.H.
1962 *Geological Report 67: Recession of Wisconsin Glacier from Central Saskatchewan*. Saskatchewan Department of Mineral Resources.
- Edwards, Thomas W. D., S. Jean Birks, Brian H. Luckman and Glen M. Macdonald
2008 Climatic and Hydrologic Variability During the Past Millennium in the Eastern Rocky Mountains and Northern Great Plains of Western Canada. *Quaternary Research* 70(2):188-197.
- Epp, H. T. and Ian G. Dyck
1983 *Tracking Ancient Hunters: Prehistoric Archaeology in Saskatchewan*. Saskatchewan Archaeological Society, Saskatoon.
- Ewers, John C.
1955 The Horse in Blackfoot Indian Culture. In *Bureau of American Ethnology Bulletin No. 159*. Smithsonian Institution, Washington, D.C.
- Feathers, J. K.
2012 Luminescence Dating of Anthropogenic Rock Structures in the Northern Rockies and Adjacent High Plains, North America: A Progress Report. *Quaternary Geochronology* 10:399-405.
- Fenton, M.M., B.T. Schreiner, E. Nielsen and J.G. Pawlowicz
1994 Chapter 26: Quaternary Geology of the Western Plains. In *Geological Atlas of the Western Canada Sedimentary Basin*, edited by G. Mossop and I. Shetsen, pp. 413-420. Alberta Research Council, Edmonton.
- Finnigan, James T.
1980 Interpreting Tipi Ring Structures. *Nap'ao: A Saskatchewan Anthropology Journal* 10:1-6.

1981 Regular or Random: The Significance of Tipi Ring Rock Distributions. In *Megaliths to Medicine Wheels: Boulder Structures in Archaeology, Proceedings of the Eleventh Annual Chacmool Conference* edited by M. Wilson, K. L. Road and K. J. Hardy, pp. 69-78. University of Calgary Archaeological Association, Calgary.

1982 *Tipi Rings and Plains Prehistory: a Reassessment of Their Archaeological Potential*. National Museums of Canada, Ottawa.
- Finnigan, James T. and Eldon Johnson
1984 The Elma Thompson Site: A Besant Phase Tipi Ring in the West-Central Saskatchewan Plains. *Saskatchewan Archaeology* 5:27-35.
- Flayharty, R. A. and Elizabeth Ann Morris
1974 T-W-Diamond, a Stone Ring Site in Northern Colorado. *Plains Anthropologist* 19(65):161-172.

Forbis, Richard G.

1960 *Contributions to Anthropology, 1957*. National Museum of Canada Bulletin 162: 119-164, Ottawa.

1970 *A Review of Alberta Archaeology to 1964*. National Museums of Canada, Publications in Archaeology 1, Ottawa.

Forner, Cheryl Irene

2005 *A Model for the Examination of Gender Within Domestic Spaces on the Northern Plains*. Unpublished M.A. thesis, Department of Archaeology and Anthropology, University of Saskatchewan, Saskatoon, SK.

Fredlund, Lynn B., Dale Herbort and Gene Munson

1985 Investigations at a Besant Stone Ring Site (320L270) in Central North Dakota. In *Contributions to Plains Prehistory*, edited by D. Burley, pp. 116-154. vol. Occasional Paper No. 26. Archaeological Survey of Alberta, Edmonton, AB.

Frison, George C., David Scwab, L. Adrien Hannus, Peter Winham, David Walter and Robert C. Mainfort

1996 Archaeology of the Northwestern Plains. In *Archaeological and Bioarchaeological Resources of the Northern Plains: A Volume in the Central and Northern Plains Archaeological Overview*, edited by G. C. Frison and R. C. Mainfort, pp. 8-40. Arkansas Archaeological Survey Research Series No. 47. Arkansas Archaeological Survey, Fayetteville.

Fulton, R. J.

1989 Foreword to the Quaternary Geology of Canada and Greenland. In *Quaternary Geology of Canada and Greenland*, edited by R. J. Fulton, pp. 1-12. vol. Geological Survey of Canada Geology of Canada No. 1. Geological Survey of Canada, Ottawa.

Garmin

2006 *GPSmap 60Cx Owner's Manual*. Liberty House, Southampton.

Giardino, M.G. and B.S. Haley

2006 Airborne Remote Sensing and Geospatial Analysis. In *Remote Sensing in Archaeology: an Explicitly North American Perspective*, edited by J. K. Johnson, pp. 47-77. University of Alabama Press, Tuscaloosa.

Gibson, Terrance

1982 *Magnetic Survey and Archaeological Site Assessment*. Unpublished M.A. thesis, Department of Anthropology, University of Alberta, Edmonton.

1986 Magnetic Prospection on Prehistoric Sites in Western Canada. *Geophysics* 51(3):553-560.

- Gilliland, Krista, Terrance Gibson, Peter Stewart, Petr Kurzybov, Rob Kadis and Cara Pollio
2016 *Flood Impact Assessment Program 2015: Historical Resources Impact Mitigation FM Ranch Campsite (EfPk-1), Archaeological Research Permit No. 15-147*. Report prepared by Western Heritage for Archaeological Survey of Alberta, St. Albert. On file with the Archaeological Survey of Alberta.
- Gilmore, Melvin R.
1913 Some Native Nebraska Plants with their Uses by the Dakota. *Collections of the Nebraska State Historical Society* 17(1):358-370.

1991 *Uses of Plants by the Indians of the Missouri River Region*. University of Nebraska Press, Lincoln.
- Gragson, T.L.
1983 A Preliminary Look at Stone Circle Site Distribution in Montana. In *From Microcosm to Macrocosm: Advances in Tipi Ring Investigations and Interpretation*, edited by L. B. Davis, pp. 139-145. *Plains Anthropologist* 28(102) Pt. 2, Memoir 19.
- Graspointner, Andreas
1980 *Archaeology and Ethnohistory of the Milk River in Southern Alberta*. Western Publishers, Calgary.
- Gray, Asa and Merritt Lyndon Fernald
1987 *Gray's Manual of Botany: A Handbook of the Flowering Plants and Ferns of the Central and Northeastern United States and Adjacent Canada*. 8th ed. Dioscorides Press, Portland.
- Greer, James E. and Earl A. Christiansen
1963 *Geology and Groundwater Resources of the Wynyard Area (72-P), Saskatchewan*. Saskatchewan Research Council, Geology Division, Regina.
- Greiser, Sally T., T. Weber Greiser and Susan M. Vetter
1985 Middle Prehistoric Period Adaptations and Paleoenvironment in the Northwestern Plains: The Sun River Site. *American Antiquity* 50(4):849-877.
- Grimm, Eric C., Joseph J. Donovan and Kendrick J. Brown
2011 A High-Resolution Record of Climate Variability and Landscape Response from Kettle Lake, Northern Great Plains, North America. *Quaternary Science Reviews* 30(19):2626-2650.
- Grinnell, George Bird
1892 Early Blackfoot History. *American Anthropologist* 5(2):153-164.
- Grove, Jean
1988 *The Little Ice Age*. Methuen, London.

- Hammer, U. Theodore
1985 Saline Lake Resources of the Canadian Prairies. *Canadian Water Resources Journal* 11(1):43-57.
- Hammermeister, Andrew M., D. Gauthier and McGovern K.
2001 *Saskatchewan's Native Prairie: Taking Stock of a Vanishing Ecosystem and Dwindling Resource*. Native Plant Society of Saskatchewan, Saskatoon, SK.
- Hanna, Don
1991 Architectural Variability in Stone Circles at EdOm-13, Near Empress, Alberta. In *Archaeology in Alberta 1988 and 1989*, edited by M. Magne, pp. 3-21. Occasional Paper No. 33. Archaeological Survey of Alberta, Edmonton, AB.
- Hanna, Don, Janet Blakey and Kendra Drever
2009 *Evaluation of Significant Medicine Wheels and Vision Quest Sites for Possible Designation as Provincial Historic Resources Final Report, Permit 2008-354*. Prepared for Historical Resources Management Branch, Alberta Culture and Community Spirit by Lifeways of Canada Ltd. On file with the Archaeological Survey of Alberta.
- Hanna, Margaret G. and Terrance Gibson
1993 Trespassing into the Past: A Report on the Workshop with Cree Elders Held on May 1-3, 1992 Joe Duquette High School and Wanuskewin Heritage Park, Saskatoon. *Saskatchewan Archaeology* 14:2-14.
- Harms, Vernon L.
1983 Native Cacti of Saskatchewan. *Blue Jay* 41:131-139.
- Hart, Catherine Leigh
2009 *High-Resolution Pollen Analysis of Two Lakes at the Boreal Forest-Aspen Parkland Ecotone*. Unpublished M.Sc. thesis, Biology Department, University of Regina, Regina.
- Hassrick, Royal B.
1964 *The Sioux: Life and Customs of a Warrior Society*. University of Oklahoma Press, Norman.
- Hather, Jon G.
2000 *The Identification of the Northern European Woods: A Guide for Archaeologists and Conservators*. Archetype Publications, London.
- Hellson, John C.
1974 *Ethnobotany of the Blackfoot Indians*. Mercury Series: Canadian Ethnology Series Paper No. 19. National Museums of Canada, Ottawa.

- Henry, J. L., E. A. Christiansen, H. K. Harder and T. J. Hogg
1990 *Soil Salinity and Groundwater Studies of the Quill Lakes-Last Mountain Lake (Wynyard-72P) Area*. Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon.
- Hind, Henry Youle
1859 *North-West Territory: Reports of Progress, Together with a Preliminary and General Report on the Assiniboine and Saskatchewan Exploring Expedition, Made Under Instructions From the Provincial Secretary, Canada*. Queen's Printer, Toronto.

1860 *Narrative of the Canadian Red River Exploring Expedition of 1857 and of the Assiniboine and Saskatchewan Exploring Expedition of 1858*. Canadian Red River and Assiniboine and Saskatchewan Expeditions. Longman, Green, Longman and Roberts, London.
- Hoadley, R. Bruce
1990 *Identifying Wood: Accurate Results with Simple Tools*. Taunton Press, Newtown.
- Holliday, Vance T.
2004 *Soils in Archaeological Research*. Oxford University Press, Oxford.
- Holter, Milton Edward
1969 *The Middle Devonian Prairie Evaporite of Saskatchewan*. Unpublished M.Sc. thesis, Department of Geological Sciences, University of Saskatchewan, Saskatoon.
- Huggett, Jeremy
2015 Challenging Digital Archaeology. *Open Archaeology* 1(1):79-85.
- Hungrywolf, Adolf
2006 *The Tipi: Traditional Native American Shelter*. Native Voices Book Publishing Co., Summertown.
- Hunter, Andrea A. and Brian R. Gassner
1998 Evaluation of the Flote-Tech Machine-Assisted Flotation System. *American Antiquity* 63(1):143-156.
- Irvine, Lee-Ann and Janis E. Dale
2012 "Pimple" Mound Microrelief in Southern Saskatchewan, Canada. In *Mima Mounds: the Case for Polygenesis and Bioturbation*, edited by J. L. Horwath Burnham and D. L. Johnson, pp. 43-62. The Geological Society of America, Boulder.
- Irwin-Williams, Cynthia, Henry Irwin, George Agogino and C. Vance Haynes
1973 Hell Gap: Paleo-Indian Occupation on the High Plains. *Plains Anthropologist* 18(59):40-53.
- Irwin, Lee
1994 *The Dream Seekers: Native American Visionary Traditions of the Great Plains*. University of Oklahoma Press, Norman.

- Jennings, Jesse D.
1985 River Basin Surveys: Origins, Operations, and Results, 1945-1969. *American Antiquity* 50(2):281-296.
- Johnson, Donald L. and Jennifer L. Horwath Burnham
2012 Introduction: Overview of Concepts, Definitions, and Principles of Soil Mound Studies. In *Mima Mounds: the Case for Polygenesis and Bioturbation*, edited by J. L. Horwath Burnham and D. L. Johnson, pp. 21-42. The Geological Society of America, Boulder.
- Johnson, Frederick
1955 Reflections Upon the Significance of Radiocarbon Dates. In *Radiocarbon Dating*, edited by W. F. Libby, pp. 141-161. 2nd ed. University of Chicago Press, Chicago.
- Johnston, Alex
1962 *Chenopodium album* as a Food Plant in Blackfoot Indian Prehistory. *Ecology* 43(1):129-130.

1970 Blackfoot Indian Utilization of the Flora of the Northwestern Great Plains. *Economic Botany* 24(3):301-324.
- Jones, Eric E.
2006 Using Viewshed Analysis to Explore Settlement Choice: A Case Study of the Onondaga Iroquois. *American Antiquity* 71(3):523-538.
- Jones, Geoffrey and Gene Munson
2005 Geophysical Survey as an Approach to the Ephemeral Campsite Problem: Case Studies from the Northern Plains. *Plains Anthropologist* 50(193):31-43.
- Joyes, Dennis C.
1973 The Shippee Canyon Site. *Archaeology of Montana* 14(2):49-85.
- Judson, Sheldon
1953 *Geology of the San Jon Site, Eastern New Mexico*. Smithsonian Miscellaneous Collections 121. Smithsonian Institution, Washington.
- Kay, Marvin
1998 The Great Plains Setting. In *Archaeology on the Great Plains*, edited by W. R. Wood, pp. 16-47. University Press of Kansas, Lawrence.
- Keane, Kahlee and David Howarth
2003 *The Standing People: Field Guide of Medicinal Plants of the Prairie Provinces*. Rev. ed. Root Woman and Dave, Saskatoon.
- Keepax, Carole
1977 Contamination of Archaeological Deposits by Seeds of Modern Origin with Particular Reference to the Use of Flotation Machines. *Journal of Archaeological Science* 4(3):221-229.

- Kehew, Alan E. and James T. Teller
1994 Glacial-Lake Spillway Incision and Deposition of a Coarse-Grained Fan near Watrous, Saskatchewan. *Canadian Journal of Earth Sciences* 31(3):544-553.
- Kehoe, Alice B.
1959 Ceramic Affiliations in the Northwestern Plains. *American Antiquity* 25(2):237-246.
- Kehoe, Thomas F.
1958 Tipi Rings: The "Direct Ethnological" Approach Applied to an Archeological Problem. *American Anthropologist* 60(5):861-873.

1960 Stone Tipi Rings in North-Central Montana and the Adjacent Portions of Alberta, Canada: Their Historical, Ethnological, and Archaeological Aspects. In *Bureau of American Ethnology Bulletin No. 173*. Smithsonian Institution, Washington, D.C.

1983 A Retrospectus and Commentary. In *From Microcosm to Macrocosm: Advances in Tipi Ring Investigations and Interpretation*, edited by L. B. Davis, pp. 326-342. *Plains Anthropologist* 28(102) Pt. 2, Memoir 19.
- Kehoe, Thomas F. and Alice B. Kehoe
1968 Saskatchewan. In *The Northwestern Plains: A Symposium*, edited by W. W. Caldwell and S. W. Conner, pp. 21-35. Occasional Paper No. 1. The Center for Indian Studies, Rocky Mountain College, Billings.
- Kennedy, Katrina
1994 Early-Holocene Geochemical Evolution of Saline Medicine Lake, South Dakota. *Journal of Paleolimnology* 10(2):69-84.
- Kenny, Raymond A.
1985 *Saskatchewan Power Corporation's 1984 Natural Gas Development Program, Heritage Resource Impact Assessment, Permit 1984-7*. On file with the Saskatchewan Heritage Conservation Branch.
- Kindscher, Kelly
1987 *Edible Wild Plants of the Prairie: An Ethnobotanical Guide*. University Press of Kansas, Lawrence, Kansas.
- Klassen, Judith
2004 Paleoenvironmental Interpretation of the Paleosols and Sediments at the Stampede Site (DjOn- 26), Cypress Hills, Alberta. *Canadian Journal of Earth Sciences* 41(6):741-753.
- Klassen, R.W.
1989 Quaternary Geology of the Southern Canadian Interior Plains. In *Quaternary Geology of Canada and Greenland*, edited by R. J. Fulton, pp. 138-174. Geological Survey of Canada Geology of Canada No. 1. Geological Survey of Canada, Ottawa.

- Kooyman, Brian P.
2000 *Understanding Stone Tools and Archaeological Sites*. University of Calgary Press, Calgary.
- Kornfeld, Marcel, George C. Frison and Mary Lou Larson
2010 *Prehistoric Hunter-Gatherers of the High Plains and Rockies*. 3rd ed. Left Coast Press, Walnut Creek.
- Kreutz, K. J., P. A. Mayewski, L. D. Meeker, M. S. Twickler, S. I. Whitlow and I. I. Pittalwala
1997 Bipolar Changes in Atmospheric Circulation During the Little Ice Age. *Science* 277(5330):1294-1296.
- Krozser, Kit and Ben Hjermstad
1995 *Stone Circle Site Treatment Review and Workshop Final Report*. Unpublished Manuscript, Saskatchewan Association of Professional Archaeologists. On file with the Saskatchewan Heritage Conservation Branch., Saskatchewan.
- Kvamme, Kenneth L.
2006 Magnetometry: Nature's Gift to Archaeology. In *Remote Sensing in Archaeology: an Explicitly North American Perspective*, edited by J. K. Johnson, pp. 205-223. University of Alabama Press, Tuscaloosa.

2008 Remote Sensing Approaches to Archaeological Reasoning: Pattern Recognition and Physical Principles. In *Archaeological Concepts for the Study of the Cultural Past*, edited by A. P. Sullivan, pp. 65-84. University of Utah Press, Salt Lake City.
- Kvamme, Kenneth L., Eileen G. Ernenwein and Christine J. Markussen
2006 Robotic Total Station for Microtopographic Mapping: An Example from the Northern Great Plains. *Archaeological Prospection* 13(2):91-102.
- Laird, Kathleen R., Brian F. Cumming, Sybille Wunsam, James A. Rusak, Robert J. Oglesby, Sherilyn C. Fritz and Peter R. Leavitt
2003 Lake Sediments Record Large-scale Shifts in Moisture Regimes Across the Northern Prairies of North America During the Past Two Millennia. *Proceedings of the National Academy of Sciences of the United States* 100(5):2483-2488.
- Lamb, Hubert H.
1972 *Climate: Present, Past and Future* Vol. II, Climatic History and the Future. Methuen, London.
- Lamoureux, Scott F. and Jaclyn M. H. Cockburn
2005 Timing and Climatic Controls over Neoglacial Expansion in the Northern Coast Mountains, British Columbia, Canada. *Holocene* 15(4):619-624.
- Lang, Amanda
2010 *Echoes of Experience: The Narrative Forces of the Qu'Appelle Valley*. Unpublished M.Sc. thesis, Department of Landscape Architecture, University of Manitoba, Winnipeg.

- Larson, Mary Lou, Marcel Kornfeld and George C. Frison
2009 *Hell Gap: A Stratified Paleoindian Campsite at the Edge of the Rockies*. University of Utah Press, Salt Lake City.
- Last, William M.
1991 *Sedimentology, Geochemistry and Evolution of Saline Lakes of the Northern Great Plains - August 17-21, 1991: Excursion Guidebook*. Department of Geological Science, University of Manitoba, Winnipeg.
- Last, William M., Jenny Deleqiat, Karen Greengrass and Sunita Sukhan
2002 Re-examination of the Recent History of Meromictic Waldsea Lake, Saskatchewan, Canada. *Sedimentary Geology* 148(1):147-160.
- Last, William M. and Fawn M. Ginn
2005 Saline Systems of the Great Plains of Western Canada: An Overview of the Limnogeology and Paleolimnology. *Saline Systems* 1(10):1-38.
- Last, William M. and Timothy H. Schweyen
1985 Late Holocene History of Waldsea Lake, Saskatchewan, Canada. *Quaternary Research* 24(2):219-234.
- Last, William M. and Laurie A. Slezak
1986 Paleohydrology, Sedimentology, and Geochemistry of Two Meromictic Saline Lakes in Southern Saskatchewan. *Géographie Physique et Quaternaire* 40(1):5.
- Last, William M. and Robert E. Vance
2002 The Holocene History of Oro Lake, one of Western Canada's Longest Continuous Lacustrine Records. *Sedimentary Geology* 148(1):161-184.
- Last, William M., Robert E. Vance, Susan E. Wilson and John P. Smol
1998 A Multi-proxy Limnologic Record of Rapid Early-Holocene Hydrologic Change on the Northern Great Plains, Southwestern Saskatchewan, Canada. *The Holocene* 8(5):503-520.
- Laubin, Reginald and Gladys Laubin
1977 *The Indian Tipi: Its History, Construction, and Use*. 2nd ed. University of Oklahoma Press, Norman.
- Lawrence, H. Lea
2002 *The Ultimate Guide to Small Game and Varmint Hunting: How to Hunt Squirrels, Rabbits, Woodchucks, Coyotes, Foxes, and Other Game Animals*. The Lyons Press, Guilford, CN.
- Lemmen, Donald S. and Robert E. Vance
1998 Climatic Variability on the Southern Canadian Prairies During the Last 1000 Years Based on Multiple Proxy Indicators. In *Proceedings of the Workshop on Decoding Canada's Environmental Past: Climate Variations and Biodiversity Change During the*

- Last Millennium*, edited by D. C. MacIver and R. E. Meyer, pp. 45-51. Environment Canada, Downsview, Ontario.
- 1999 An Overview of the Palliser Triangle Global Change Project. In *Holocene Climate and Environmental Change in the Palliser Triangle: A Geoscientific Context for Evaluating the Impacts of Climate Change on the Southern Canadian Prairies*, edited by D. S. Lemmen and R. E. Vance, pp. 7-22. Geological Survey of Canada, Calgary.
- Lesch, S.M. and D.L. Suarez
 2009 Technical Note: A Short Note on Calculating the Adjusted SAR Index. *Transactions of the American Society of Agricultural and Biological Engineers* 52(2):493-496.
- Lewarch, Dennis E., Amy Dugas, Leonard Forsman and Lynn Larson
 1998 *Cultural Resource Evaluation of Sites 24GL40 and 24GL41, Browning-Meriwether Road Reconstruction Project F1-3(12)225f, Glacier County, Montana*.
- Lewis, Theodore Hayes
 1889 Stone Monuments in Southern Dakota. *American Anthropologist* 2(2):159-166.
- Leyden, Jeremy J., Leonard I. Wassenaar, Keith A. Hobson and Ernest G. Walker
 2006 Stable Hydrogen Isotopes of Bison Bone Collagen as a Proxy for Holocene Climate on the Northern Great Plains. *Palaeogeography, Palaeoclimatology, Palaeoecology* 239(1):87-99.
- Linnamae, Urve
 1983 Coffin Site Update - Summer 1983. *Saskatchewan Archaeological Society Newsletter* 4(5):50-51.
- 1995 Stone Circles and Tipi Rings at the Coffin Site, Central Saskatchewan. In *Stone Circles and Tipi Rings at the Coffin Site, Central Saskatchewan/ The Lozinsky Site: A Late Pre-Contact Bison Processing Camp*, edited by U. Linnamae and M. E. Malainey, pp. 1-72. vol. Occasional Paper No. 1. Saskatoon Archaeological Society, Saskatoon.
- Lock, G. R. and T. M. Harris
 1996 Danebury Revisited: An Iron Age Hillfort in a Digital Landscape. In *Anthropology, Space, and Geographic Information Systems*, edited by M. S. Aldenderfer and H. D. Maschner, pp. 214-240. Oxford University Press, Oxford.
- Long, Jennifer K.
 2011 *An Analysis of Stone Circle Site Structure on the Pawnee National Grassland, Weld County, Colorado*. Unpublished M.A. thesis, Department of Anthropology, Colorado State University, Fort Collins.
- Lowe, John and Mike Walker
 2015 *Reconstructing Quaternary Environments*. 3rd ed. Routledge, London.

- Lowie, Robert Harry
1963 *Indians of the Plains*. The Natural History Press, Garden City.
- Maathuis, H. and Bryan Thomas Schreiner
1982 *Hatfield Valley Aquifer System in the Wynyard Region, Saskatchewan*. Saskatchewan Research Council, Saskatoon.
- MacDonald, Max
1999 *The Dam the Drought Built: a History of the South Saskatchewan River Project*. University of Regina, Canadian Plains Research Center, Regina.
- MacKinnon, Andy, Linda Kershaw, John Arnason, Patrick Owen, Amanda Karst and Fiona Hamersley Chambers
2009 *Edible and Medicinal Plants of Canada*. Lone Pine Publishing, Edmonton.
- Magee, Michael
1997 *Faunal Analysis of the Sanderson Site (DhMs-12), Block Seven West*. Unpublished M.A. thesis, Department of Anthropology and Archaeology, University of Saskatchewan, Saskatoon.
- Malainey, Mary E.
1991 *Internal and External Relationships of Saskatchewan Plains Pottery Assemblages: Circa A.D. 1300 to Contact*. Unpublished M.A. thesis, Department of Anthropology and Archaeology, University of Saskatchewan, Saskatoon.
- Malouf, Carling
1961 The Tipi Rings of the High Plains. *American Antiquity* 26(3):381-389.
- Mandelbaum, David Goodman
1979 *The Plains Cree*. 1st ed. AMS Press, New York.
- Mann, Michael E.
2002 Little Ice Age. In *The Encyclopedia of Global Environmental Change*, edited by R. E. Munn. John Wiley and Sons, Ltd., Chichester.
- Markgraf, Vera and Tom Lennon
1986 Paleoenvironmental History of the Last 13,000 years of the Eastern Powder River Basin, Wyoming, and its Implications for Prehistoric Cultural Patterns. *Plains Anthropologist* 31(111):1-12.
- Marles, Robin James, Christina Clavelle, Leslie Monteleone, Natalie Tays and Donna Burns
2008 *Aboriginal Plant Use in Canada's Northwest Boreal Forest*. Northern Forestry Centre, Edmonton.
- Martin, Alexander Campbell and William D. Barkley
1961 *Seed Identification Manual*. University of California Press, Berkeley.

McCrary, David

2001 History of the Canadian Plains Since 1870. In *Handbook of North American Indians, Volume 13: Plains (Part 1)*, edited by R. J. DeMallie, pp. 313-328. Smithsonian Institution, Washington.

McDougall, Frank H.

2000 *A Guide to Some of the Surficial Geological Features of the Little Manitou Lake Area, Saskatchewan*. Paper presented at the Saskatchewan Archaeological Society 2000 Annual Meeting held at Manitou Springs, Saskatoon.

McLean, J. R.

1971 *Stratigraphy of the Upper Cretaceous Judith River Formation in the Canadian Great Plains*. Mercury Printers, Saskatoon.

Meyer, David

1984 Anent the Pehonan Complex. *Saskatchewan Archaeology* 5:43-46.

1988 The Old Women's Phase on the Saskatchewan Plains: Some Ideas. In *Archaeology in Alberta 1987*, edited by M. Magne, pp. 55-63. Occasional Paper No. 32. Archaeological Survey of Alberta, Edmonton.

Meyer, David and H. T. Epp

1990 North-South Interactions in the Late Prehistory of Central Saskatchewan. *Plains Anthropologist* 35(132):321-342.

Michels, Astrid, Kathleen R. Laird, Susan E. Wilson, David Thomson, Peter R. Leavitt, Robert J. Oglesby and Brian F. Cumming

2007 Multidecadal to Millennial-scale Shifts in Drought Conditions on the Canadian Prairies over the Past Six Millennia: Implications for Future Drought Assessment. *Global Change Biology* 13(7):1295-1307.

Millar, J. B.

1976 *Wetland Classification in Western Canada: a Guide to Marshes and Shallow Open Water Wetlands in the Grasslands and Parklands of the Prairie Provinces*. Canadian Wildlife Service, Environment Canada, Ottawa.

Millar, J. F. V. and Stella R.M. Gromadko

1981 The Middle Arm River Valley in Prehistory. In *Chamberlain Crossroads: A Trip Back in Time*. Chamberlain Historical Society, Chamberlain.

Minnis, Paul E.

1981 Seeds in Archaeological Sites: Sources and Some Interpretive Problems. *American Antiquity* 46(1):143-152.

Mobley, Charles M.

1983 Statistical Analysis of Tipi Ring Diameters at Sites Near Santa Rosa, New Mexico. In *From Microcosm to Macrocosm: Advances in Tipi Ring Investigations and*

- Interpretation*, edited by L. B. Davis, pp. 101-112. *Plains Anthropologist* 28(102) Pt. 2, Memoir 19.
- Montana SHPO
2002 *Recordation Standards and Evaluation Guidelines for Stone Circle Sites*. Planning Bulletin No. 22. Montana State Historic Preservation Office, Helena.
- Montgomery, F. H.
1977 *Seeds and Fruits of Plants of Eastern Canada and Northeastern United States*. University of Toronto Press, Toronto.
- Moore, John H.
1996 *The Cheyenne*. Blackwell Publishers, Cambridge.
- Morris, Christopher G. (editor)
1992 *Academic Press Dictionary of Science and Technology*. Academic Press, San Diego.
- Mulloy, William
1952 The Northern Plains. In *Archeology of Eastern United States*, edited by J. B. Griffin, pp. 124-138. University of Chicago Press, Chicago.

1965 Archaeological Investigations Along the North Platte River in Eastern Wyoming. *University of Wyoming Publications* 31(2):23-51.
- Mulloy, William and Louis C. Steege
1967 Continued Archaeological Investigations Along the North Platte River in Eastern Wyoming. *University of Wyoming Publications* 33(3):169-233.
- Murray, John C., Mark J. Neal and Frédéric Labrosse
2013 Development and Deployment of an Intelligent Kite Aerial Photography Platform (iKAPP) for Site Surveying and Image Acquisition. *Journal of Field Robotics* 30(2):288-307.
- Nathan, Ran, Frank M. Schurr, Orr Spiegel, Ofer Steinitz, Ana Trakhtenbrot and Asaf Tsoar
2008 Mechanisms of Long-distance Seed Dispersal. *Trends in Ecology Evolution* 23(11):638-647.
- Nernberg, D. and D. Ingstrup
2005 *Prairie Conservation in Canada: The Prairie Conservation Action Plan Experience*. General Technical Report PSW-GTR-191. USDA Forest Service.
- Nicholson, B.A., David Meyer, Gerald A. Oetelaar and Scott Hamilton
2011 Human Ecology of the Canadian Prairie Ecozone ca. 500 BP: Plains Woodland Influences and Horticultural Practices. In *Human Ecology of the Canadian Prairie Ecozone*, edited by B.A. Nicholson (editor). Canadian Plains Research Center, University of Regina, Regina.

Nickel, Robert K.

1977 The Study of Archaeologically Derived Plant Materials from the Middle Missouri Subarea. In *Trends in Middle Missouri Prehistory: A Festschrift Honoring the Contributions of Donald J. Lehmer*, edited by W. R. Wood, pp. 53-58. *Plains Anthropologist* 28(78) Pt. 2, Memoir 13.

Norris, Dave

2010 *Detailed Assessment Heritage Resource Impact Assessment of Temporary and Permanent Access Roads to Shelter Bay Energy Inc. Well Site LSD 16-31-1-5-W2, HRIA Permit # 09-233*. Prepared for Shelter Bay Energy Inc. by Western Heritage. On file with the Saskatchewan Heritage Conservation Branch.

Oetelaar, Gerald A.

2000 Beyond Activity Areas: Structure and Symbolism in the Organization and Use of Space InsideTipis. *Plains Anthropologist* 45(171):35-61.

2003 Tipi Rings and Alberta Archaeology: A Brief Overview. In *Archaeology in Alberta: A View from the New Millennium* edited by J. Brink and J. F. Dormaar, pp. 104-130. Archaeological Society of Alberta, Medicine Hat.

2004 Stone Circles, Social Organization, and Special Places: Forbis' Skepticism Revisted. In *Archaeology on the Edge: New Perspectives from the Northern Plains*, edited by B. P. Kooyman and J. H. Kelley, pp. 125-155. University of Calgary Press, Calgary.

Ogaard, L. A., J. A. Leitch., D. F. Scott and W. C. Nelson

1981 *The Fauna of the Prairie Wetlands: Research Methods and Annotated Bibliography* Research Report 86. North Dakota State University, Agricultural Experiment Station, Fargo, North Dakota.

Owac, M. A.

2006 Beyond Geoarchaeology: Pragmatist Explorations of Alternative Viewscapes in the British Bronze Age and Beyond. In *Space and Spatial Analysis in Archaeology*, edited by E. C. Robertson, J. Seibert, D. Fernandex and M. Zender, pp. 3-13. University of Calgary Press, Calgary.

Pearsall, Deborah M.

1989 *Paleoethnobotany: a Handbook of Procedures*. 2nd ed. Academic Press, San Diego.

Peck, Trevor R.

2011 *Light From Ancient Campfires Archaeological Evidence for Native Lifeways on the Northern Plains*. AU Press, Edmonton.

- Peck, Trevor R. and C.R. Hudecek-Cuffe
2003 Archaeology on the Alberta Plains: The Last 2000 Years. In *Archaeology in Alberta: A View from the New Millennium*, edited by J. Brink and J. F. Dormaar, pp. 104-130. Archaeological Society of Alberta, Medicine Hat.
- Peck, Trevor R. and John W. Ives
2001 Late Side-Notched Projectile Points in the Northern Plains. *Plains Anthropologist* 46(176):163.
- Persooone, Guido, Patrick Sogeloos, Oswald Roeld and Edmonde Jaspers
1980 The Brine Shrimp *Artemia*. *Proceedings of the International Symposium on the Brine Shrimp Artemia salina, Texas 1979*.
- Peterson, Lynelle A.
1997 In Search of Patterns: An Examination of Artifact Distribution Patterns Within Completely Excavated Stone Rings at the Bees Nest Site in Central North Dakota. *Archaeology of Montana* 38(2):39-54.
- Pietsch, Timothy J., Jonathan M. Olley and Gerald C. Nanson
2008 Fluvial Transport as a Natural Luminescence Sensitiser of Quartz. *Quaternary Geochronology* 3(4):365-376.
- Pillans, B. and P. Gibbard
2012 The Quaternary Period. In *The Geologic Time Scale 2012*, edited by F. M. Gradstein, pp. 979-1010. Elsevier, Oxford.
- Pohorecky, Zenon
1959 *The South Saskatchewan Archaeological Report*. Report prepared for the Saskatchewan Museum of Natural History, Berkeley. On file with the Saskatchewan Heritage Conservation Branch.
- Pomeroy, J.W., D. de Boer and L.W. Martz
2007 Hydrology and Water Resources. In *Saskatchewan: Geographic Perspectives*, edited by B. D. Thraves, M. L. Lewry, J. E. Dale and H. Schlichtmann, pp. 63-80. University of Regina, Canadian Plains Research Center, Regina.
- Porter, Stephen C. and G.H. Denton
1967 Chronology of Neoglaciation in the North American Cordillera. *American Journal of Science* 265:177-210.
- Puseman, Kathryn, Linda Scott-Cummings and Thomas E. Moutoux
1999 Pollen and Macrofloral Analysis at Site 24HL948 in the Express Pipeline Route Montana Segment. In *Cultural Investigations along the Montana Segment of the Express Pipeline. Volume 7: Stone Ring Investigations Including the Lonesome Lake Traditional Cultural Property and Archaeological District Along the Express Pipeline*, edited by J. Boughton, B. Fandrich, K. Deaver and S. Deaver. Prepared for Express Pipeline Inc. by Ethnoscience Inc., Billings, MT.

Quigg, J. Michael

1979 Comments on the Significance of Stone Circle Excavations in Alberta. *Plains Anthropologist* 24(85):261-266.

1981 Stone Circle Excavations in Alberta to 1978: A Summary. In *Megaliths to Medicine Wheels: Boulder Structures in Archaeology, Proceedings of the Eleventh Annual Chacmool Conference* edited by M. Wilson, K. L. Road and K. J. Hardy, pp. 47-68. University of Calgary Archaeological Association, Calgary.

1986 Ross Glen: a Besant Stone Circle Site in Southeastern Alberta. Occasional Paper No. 10. Archaeological Survey of Alberta, Edmonton, Alberta.

Quigg, J. Michael and John H. Brumley

1984 *Stone Circles: A Review Appraisal and Future Directions*. Report prepared for and published by the Division of Archaeology and Historic Preservation, State Historical Society of North Dakota.

Ramsay, Charles L.

1993 *The Redtail Site: A McKean Habitation in South Central Saskatchewan*. Unpublished M.A. thesis, Department of Anthropology and Archaeology, University of Saskatchewan, Saskatoon.

Rawson, D.S. and J.E. Moore

1944 *The Saline Lakes of Saskatchewan*. National Research Council of Canada, Ottawa.

Ray, Arthur J.

1998 *Indians in the Fur Trade: Their Role as Trappers, Hunters, and Middlemen in the Lands Southwest of Hudson Bay, 1660-1870*. University of Toronto Press, Toronto.

Reeves, Brian O.K.

1983a *Culture Change in the Northern Plains: 1000 BC - AD 1000*. Occasional Paper No. 20. Archaeological Survey of Alberta, Edmonton.

1983b The Kenney Site: A Stratified Campsite in Southwestern Alberta. *Archaeology of Montana* 24(1):1-136.

1985 Northern Plains Culture Historical Systematics. In *Contributions to Plains Prehistory*, edited by D. Burley, pp. 3-21. Occasional Paper No. 26. Archaeological Survey of Alberta, Edmonton, AB.

Rescan

2011 *Young Project: Heritage Resource Impact Assessment Permit No. 10-127*. Prepared for BHP Billiton by Rescan Environmental Services Ltd.

2012a *Young Project: 2009-2011 Biophysical and Socio-economic Baseline Studies*. Prepared for BHP Billiton by Rescan Environmental Services Ltd.

- 2012b *Young Project: Heritage Resource Impact Assessment Permit No. 11-105*.
Prepared for BHP Billiton by Rescan Environmental Services Ltd.
- 2013 *Young Project: Heritage Resource Impact Assessment Permit No. 12-090*.
Prepared for BHP Billiton by Rescan Environmental Services Ltd.
- Riehl-Fitzsimmons, Belinda, Talina Cyr-Steenkamp and Frank McDougall
2013 *Sifting Through Time: a History of the Saskatchewan Archaeological Society*.
Saskatchewan Archaeological Society, Saskatoon.
- Ritchie, J. C.
1976 The Late-Quaternary Vegetational History of the Western Interior of Canada.
Canadian Journal of Botany 54(15):1793-1818.
- Roberts, Richard G., Zenobia Jacobs, Bo Li, Nathan R. Jankowski, Alastair C. Cunningham and
Anatoly B. Rosenfeld
2015 Optical Dating in Archaeology: Thirty Years in Retrospect and Grand Challenges
for the Future. *Journal of Archaeological Science* 56:41-60.
- Robertson, Elizabeth C.
2011 Reassessing Hypsithermal Human-Environment Interaction on the Northern
Plains. *Geological Society Special Publication* 352:181-194.
- Rogers, Dilwyn J.
1980 *Edible, Medicinal, Useful, and Poisonous Wild Plants of the Northern Great
Plains-South Dakota Region*. Buechel Memorial Lakota Museum, St. Francis.
- Roll, Tom E.
1981 Tipi Rings of North-Central Montana: Expression and Analysis. In *Megaliths to
Medicine Wheels: Boulder Structures in Archaeology, Proceedings of the Eleventh
Annual Chacmool Conference*, edited by M. Wilson, K. L. Road and K. J. Hardy, pp. 79-
92. University of Calgary Archaeological Association, Calgary.
- Rollans, Maureen
1990 *A Handbook for Teaching Archaeology in Saskatchewan Schools*. Saskatchewan
School Trustees Association Research Centre, Regina.
- Sack, Lisa and William M. Last
1994 Lithostratigraphy and Recent Sedimentation History of Little Manitou Lake,
Saskatchewan, Canada. *Journal of Paleolimnology* 10(3):199-212.
- Sanderson, David C. W. and Simon Murphy
2010 Using Simple Portable OSL Measurements and Laboratory Characterisation to
Help Understand Complex and Heterogeneous Sediment Sequences for Luminescence
Dating. *Quaternary Geochronology* 5(2):299-305.

Saskatchewan Forage Council

2002 *Field Guide: Identification of Common Range Plants of Southern Saskatchewan*. Saskatchewan Agriculture and Food, Regina.

Saskatchewan Soil Survey

1990 *Rural Municipality of Viscount No. 341: Preliminary Soil Map and Report*. 4th ed. University of Saskatchewan, Saskatoon.

1991 *The Soils of Morris, Rural Municipality No. 312 Saskatchewan*. 4th ed. University of Saskatchewan, Saskatoon.

Saskatchewan Watershed Authority

2008 *Getting to the Source: Upper Qu'Appelle River and Wascana Creek Watersheds Source Water Protection Plan*. Saskatchewan Watershed Authority, Regina, SK.

Sauchyn, David J.

1997 Proxy Records of Postglacial Climate in the Canadian Prairie Provinces: A Guide to the Literature and Current Research. In *Responding to Global Climate Change in the Prairies, Volume III of the Canada Country Study: Climate Impacts and Adaptation*, edited by R. Herrington, B. Johnson and F. Hunter. Appendix I pp. 1-44. Environment Canada, Prairie and Northern Region, Regina.

Sauchyn, David J. and Alwynne B. Beaudoin

1998 Recent Environmental Change in the Southwestern Canadian Plains. *The Canadian Geographer* 42(4):337-353.

Sauchyn, David J. and M.I. Vélez

2007 Holocene Climate Change. In *Saskatchewan: Geographic Perspectives*, edited by B. D. Thraves, M. L. Lewry, J. E. Dale and H. Schlichtmann, pp. 57-62. University of Regina, Canadian Plains Research Center, Regina.

Sauchyn, Mary A. and David J. Sauchyn

1991 A Continuous Record of Holocene Pollen from Harris Lake, Southwestern Saskatchewan, Canada. *Palaeogeography, Palaeoclimatology, Palaeoecology* 88(1):13-23.

Scheiber, Laura Lee

1993 *Prehistoric Domestic Architecture on the Northwestern High Plains: a Temporal Analysis of Stone Circles in Wyoming*. Unpublished M.A. thesis, Department of Anthropology, University of Wyoming, Laramie, WY.

Scheiber, Laura Lee and Judson Byrd Finley

2010 Domestic Campsites and Cyber Landscapes in the Rocky Mountains. *Antiquity* 84(323):114-130.

Schellenberg, Ruth Mary

1996 *Lake of the Healing Waters: Manitou Beach, Saskatchewan, Canada*. Star Books, Watrous, SK.

- Schiffer, Michael B.
1987 *Formation Processes of the Archaeological Record*. 1st ed. University of New Mexico Press, Albuquerque.
- Schneider, Frederick E. and Patricia A. Treat
1974 *Archaeological Investigations at the Sprenger Tipi Ring Site, 32Sh205, Sheridan County, North Dakota: An Archaeological Salvage Project in the Garrison Diversion Unit*. Report to the US National Park Service 1. Midwest Archaeological Center, Lincoln.
- Schweyen, Timothy H. and William M. Last
1983 *Sedimentology and Paleohydrology of Waldsea Lake, Saskatchewan*. Third Biennial Plains Aquatic Research Conference: Proceedings August 24 and 25, 1983. Montana State University, Bozeman, Montana.
- Shang, Y. and William M. Last
1999 Mineralogy, Lithostratigraphy, and Inferred Geochemical History of North Ingebrigt Lake, Saskatchewan. In *Holocene Climate and Environmental Change in the Palliser Triangle: A Geoscientific Context for Evaluating the Impacts of Climate Change on the Southern Canadian Prairies*, edited by D. S. Lemmen and R. E. Vance, pp. 95-110. Geological Survey of Canada, Calgary.
- Sheriff, Steven D.
2013 Total Field Magnetic Exploration for Prehistoric Archaeological Sites Along Yellowstone Lake's Northwest Shore. In *Yellowstone Archaeology: Southern Yellowstone*, edited by D. MacDonald and E. Hale, pp. 195-210 vol. 13 Contributions to Anthropology. Department of Anthropology, University of Montana Missoula.
- Shillibeer, Carol
1995 *Sweetgrass Innovations in Native and New Age Communities*. Unpublished M.A. thesis, Department of Anthropology, University of Calgary.
- Shot Gun World
2003a *Game and Suggested Shot Size Table*. <http://www.shotgunworld.com/amm.html>, accessed January 27, 2016.

2003b *Shot Size Table*. http://www.shotgunworld.com/ammo_s082000.html, accessed March 3, 2016.
- Simpson, M. A.
2000 *Geology and Hydrostratigraphy of the Wynyard Area (72P), Saskatchewan*.
- Smith, Marc B.
1974 Rapid Method for Recording Stone Circles. *Archaeology of Montana* 15(3):47-54.
- Soil Classification Working Group
1998 *The Canadian System of Soil Classification*. 3rd ed. National Research Council Research Press, Ottawa.

- Sproule, Jean (ed.)
1984 *Prairie Reflections: Watrous, Venn, Manitou Beach, Renown, Amazon and Districts*. Watrous and District History Committee, Watrous.
- Spry, Irene M.
1995 *The Palliser Expedition: the Dramatic Story of Western Canadian Exploration, 1857-1860*. 2nd ed. Fifth House, Saskatoon.
- St. Jacques, Jeannine-Marie, Brian F. Cumming and John P. Smol
2008 A 900-Year Pollen-Inferred Temperature and Effective Moisture Record from Varved Lake Mina, West-Central Minnesota, USA. *Quaternary Science Reviews* 27(7-8):781-796.
- Stang, D.M., E.J. Rhodes and A.M. Heimsath
2012 Assessing Soil Mixing Processes and Rates Using a Portable OSL-IRSL Reader: Preliminary Determinations. *Quaternary Geochronology* 10:314-319.
- Stead, Lauren
2013 *Geoarchaeology at the Red Tail Site: Paleoenvironmental Reconstruction of Climate Change During the Holocene*. Unpublished M.A. thesis, Department of Archaeology and Anthropology, University of Saskatchewan, Saskatoon, SK.
- Stuart, Glenn S. L.
1990 *The Cranford Site (DIPb-2): a Multicomponent Stone Circle Site on the Oldman River*. Occasional Paper No. 17. Archaeological Survey of Alberta, Edmonton.
- Taylor, R. E.
1987 *Radiocarbon Dating: an Archaeological Perspective*. Academic Press, Orlando.

2000 The Introduction of Radiocarbon Dating. In *It's About Time: A History of Archaeological Dating in North America*, edited by S. E. Nash, pp. 84-104. University of Utah Press, Salt Lake City.
- Tilley, Christopher
1996 The Powers of Rocks: Topography and Monument Construction on Bodmin Moor. *World Archaeology* 28(2):161-176.
- Transport Canada
2012 *Flying a Drone or An Unmanned Air Vehicle (UAV) for Work or Research*. Transport Canada, Government of Canada, Ottawa.
http://www.tc.gc.ca/eng/civilaviation/standards/general-recavi-uav-2265.htm?campaign=2014-uav-socialmedia-facebook&WT.mc_id=hruzf#safety, accessed May 19, 2016.
- van der Kamp, Garth, Dwayne Keir and Marlene S. Evans
2008 Long-Term Water Level Changes in Closed-Basin Lakes of the Canadian Prairies. *Canadian Water Resources Journal* 33(1):23-38.

Van Dyke, Stanley

1994 *Oldman River Dam Prehistoric Archaeology Mitigation Program, Technical Series No. 1. Campsite Study 1988-1991. ASA Permits 88-39, 89-25, 90-25, 91-05.* Prepared for Alberta Public Works, Supply and Services by Bison Historical Services Ltd. On file with the Archaeological Survey of Alberta.

van Stempvoort, D., T. Edwards, M. Evans and William M. Last

1993 Paleohydrology and Paleoclimate Records in a Saline Prairie Lake Core: Mineral, Isotope and Organic Indicators. *Journal of Paleolimnology* 8(2):135-147.

Vance, Robert E.

1991 *A Paleobotanical Study of Holocene Drought Frequency in Southern Alberta.* Unpublished Ph.D. dissertation, Department of Biological Sciences, Simon Fraser University, Burnaby.

Vance, Robert E., Alwynne B. Beaudoin and Brian H. Luckman

1995 The Paleoecological Record of 6 ka BP Climate in the Canadian Prairie Provinces. *Géographie Physique et Quaternaire* 49(1):81-89.

Vickers, J. Roderick

1986 *Alberta Plains Prehistory: A Review.* Occasional Paper No. 27. Archaeological Survey of Alberta, Edmonton, AB.

1994 Cultures of the Northwestern Plains: From the Boreal Forest Edge to Milk River. In *Plains Indians, A.D. 500-1500: The Archaeological Past of Historic Groups*, edited by K. H. Schlesier, pp. 3-33. University of Oklahoma Press, Norman.

Vickers, J. Roderick and R.I. Hastings

2005 *The Architecture of Sundial Medicine Wheel: Inferences from Lichen Studies.* Paper presented at the 63rd Annual Plains Anthropological Conference, Edmonton.

Viscount and Area History Book Committee

1985 *Footprints of Time: Viscount and District, 1905-1985.* Viscount and Area History Book Committee, Viscount, SK.

Vivian, Brian and Brian O.K. Reeves

2006 *Historical Resource Impact Assessment Benign Heritage Windfarm Final Report, Permit 2006-385.* Prepared for Benign Energy by Lifeways of Canada Ltd. On file with the Archaeological Survey of Alberta.

Vreeken, W.J.

1999 Geomorphic Surfaces and Postglacial Landscape Evolution of the Maple Creek Basin, Saskatchewan. In *Holocene Climate and Environmental Change in the Palliser Triangle: A Geoscientific Context for Evaluating the Impacts of Climate Change on the Southern Canadian Prairies*, edited by D. S. Lemmen and R. E. Vance, pp. 267-294. Geological Survey of Canada, Calgary.

- Walde, Dale A.
 2003 *The Mortlach Phase* Occasional Paper No. 2. Archaeological Society of Alberta, Calgary.
- 2004 Mortlach and One-Gun: Phase to Phase. In *Archaeology on the Edge: New Perspectives from the Northern Plains*, edited by B. P. Kooyman and J. H. Kelley, pp. 39-51. University of Calgary Press, Calgary.
- Walde, Dale A., David Meyer and Wendy Unfreed
 1995 The Late Period on the Canadian and Adjacent Plains. *Revista de Arqueología Americana* (9):7-66.
- Walker, Ernest G.
 1983 *Archaeological Resource Assessment: The Tipperary Creek Project*. Manuscript on file, Meewasin Valley Authority, Saskatoon.
- 1988 The Archaeological Resources of the Wanuskewin Heritage Park. In *Out of the Past: Sites, Digs and Artifacts in the Saskatoon Area*, edited by U. Linnamae and T. E. H. Jones, pp. 75-89. Saskatoon Archaeological Society, Saskatoon.
- 2000 Precontact Archaeology in Southern Saskatchewan. In *Atlas of Saskatchewan*, edited by Ka-iu Fung, pp. 20-29. University of Saskatchewan, Saskatoon.
- Wandsnider, LuAnn
 1997 The Roasted and the Boiled: Food Composition and Heat Treatment with Special Emphasis on Pit-Hearth Cooking. *Journal of Anthropological Archaeology* 16(1):1-48.
- Ward, R.C. and M. Robinson
 2000 *Principles of Hydrology*. McGraw-Hill Co., London.
- Watrall, Charles R.
 1979 Interim Report on Initial Investigations at the Lake Midden Site (EfNg-1). *Saskatchewan Archaeological Society Newsletter* 54(3, 4):24-31.
- Watrous-Manitou Beach Heritage Centre
 2012 *Manitou Beach Pictures*. <http://watrousheritage.ca/ManitouBeachPictures.php>, accessed April 12, 2015.
- Watrous History Book Society
 1983 *Prairie Reflections*. Watrous and District History Committee, Watrous.
- Wedel, Waldo Rudolph
 1948 *Prehistory of the Missouri Valley Development Program*. Smithsonian Miscellaneous Collections 3. 2 vols. Smithsonian Institution, Washington.
- 1961 *Prehistoric Man on the Great Plains*. University of Oklahoma Press, Norman.
- Wettlaufer, Boyd and William J. Mayer-Oakes

- 1960 *The Long Creek Site*. Saskatchewan Museum of Natural History, Department of Natural Resources, Regina.
- Wheeler, A.O.
1984 *Township Plot for TP 32, R19, W2*. Dominion Land Surveys, Ottawa.
- Wilson, James S.
1984 The Lucky Strike Site: A Late Prehistoric Campsite in the Aspen Parkland. *Saskatchewan Archaeology* 5:5-26.
- Wilson, Michael C.
1983 A Test of the Stone Circle Size-Age Hypothesis: Alberta and Wyoming. In *From Microcosm to Macrocosm: Advances in Tipi Ring Investigations and Interpretation*, edited by L. B. Davis, pp. 113-137. *Plains Anthropologist* 28(102) Pt. 2, Memoir 19.

1995 The Household as a Portable Mnemonic Landscape: Archaeological Implications for Plains Stone Circle Sites. In *Beyond Subsistence: Plains Archaeology and the Postprocessual Critique*, edited by P. G. Duke and M. C. Wilson, pp. 169-192. University of Alabama Press, Tuscaloosa.
- Wilson, Michael C., Kathie L. Road and Kenneth J. Hardy
1981 *Megaliths to Medicine Wheels: Boulder Structures in Archaeology, Proceedings of the Eleventh Annual Chacmool Conference*. University of Calgary Archaeological Association, Calgary.
- WMO (World Meteorological Organization)
2008 *Guide to Meteorological Instruments and Methods of Observation, WMO-No. 8 Seventh edition*. World Meteorological Organization.
<http://www.wmo.int/pages/prog/www/IMOP/CIMO-Guide.html>, accessed August 2016.
- Wood, W. Raymond
1998 Introduction. In *Archaeology on the Great Plains*, edited by W. R. Wood, pp. 1-15. University Press of Kansas, Lawrence.
- Wormington, H. M.
1965 *An Introduction to the Archaeology of Alberta, Canada*. Proceedings 11, Denver Museum of Natural History, Denver.
- Wright, H. E.
1976 The Dynamic Nature of Holocene Vegetation: A Problem in Paleoclimatology, Biogeography, and Stratigraphic Nomenclature. *Quaternary Research* 6(4):581-596.
- Yansa, Catherine H.
2007 Lake Records of Northern Plains Paleoindian and Early Archaic Environments: The "Park Oasis" Hypothesis. *Plains Anthropologist* 52(201):109-144.

- Yansa, Catherine H. and J.F. Basinger
 1999 A Postglacial Plant Macrofossil Record of Vegetation and Climate Change in Southern Saskatchewan. In *Holocene Climate and Environmental Change in the Palliser Triangle: A Geoscientific Context for Evaluating the Impacts of Climate Change on the Southern Canadian Prairies*, edited by D. S. Lemmen and R. E. Vance, pp. 139-172. Geological Survey of Canada, Calgary.
- Young, Patrick and Michael Markowski
 2009 *PetroBakken Developments Ltd. Final Mitigation Report for DkMr-33 and DkMr-34 - Permit No. 09-158*, Report on file with the Heritage Conservation Branch.
- Yu, Zicheng, Emi Ito, Daniel R. Engstrom and Sherilyn C. Fritz
 2002 A 2100-Year Trace-Element and Stable-Isotope Record at Decadal Resolution from Rice Lake in the Northern Great Plains, USA. *The Holocene* 12(5):605-617.
- Ziebart, Marek, Nick Holder and Peter Dare
 2002 Field Digital Data Acquisition (FDA) Using Total Station and Pencomputer: A Working Methodology. In *Contemporary Themes in Archaeological Computing*, edited by D. Wheatley, G. Earl and S. Poppy. University of Southampton Department of Archaeology Monograph No. 3. Oxbow Books, Oxford.
- Zoltai, Stephen C. and Dale H. Vitt
 1990 Holocene Climatic Change and the Distribution of Peatlands in Western Interior Canada. *Quaternary Research* 33(2):231-240.
- Zomora, Mar
 2007 Total and Cumulative Viewshed: An Application in the Genil River Valley. In *The World is in Your Eyes: CAA2005: Computer Applications and Quantitative Methods in Archaeology. Proceedings of the 33rd Conference, Tomar, March 2005*, edited by A. Figueiredo and V. G., pp. 313-318. CAAPortugal, Tomar.

Appendix A

Magnetometry Results and Mapped Stone Circles

This appendix presents the results of magnetometry surveys paired with the mapped locations of surface rocks for archaeological sites EkNj-4 (Section A1), EkNj-68 (Section A2), and EkNk-3 (Section A3). Site maps illustrating the locations of each magnetometry grid area are presented at the start of each section for ease of reference. Excavation targets which were identified from the results of the magnetometry surveys but not excavated during the course of this study are illustrated for future research/reference. In addition, feature data recorded for stone circles at EkNj-68 are presented in Section A2.

A1. EkNj-4

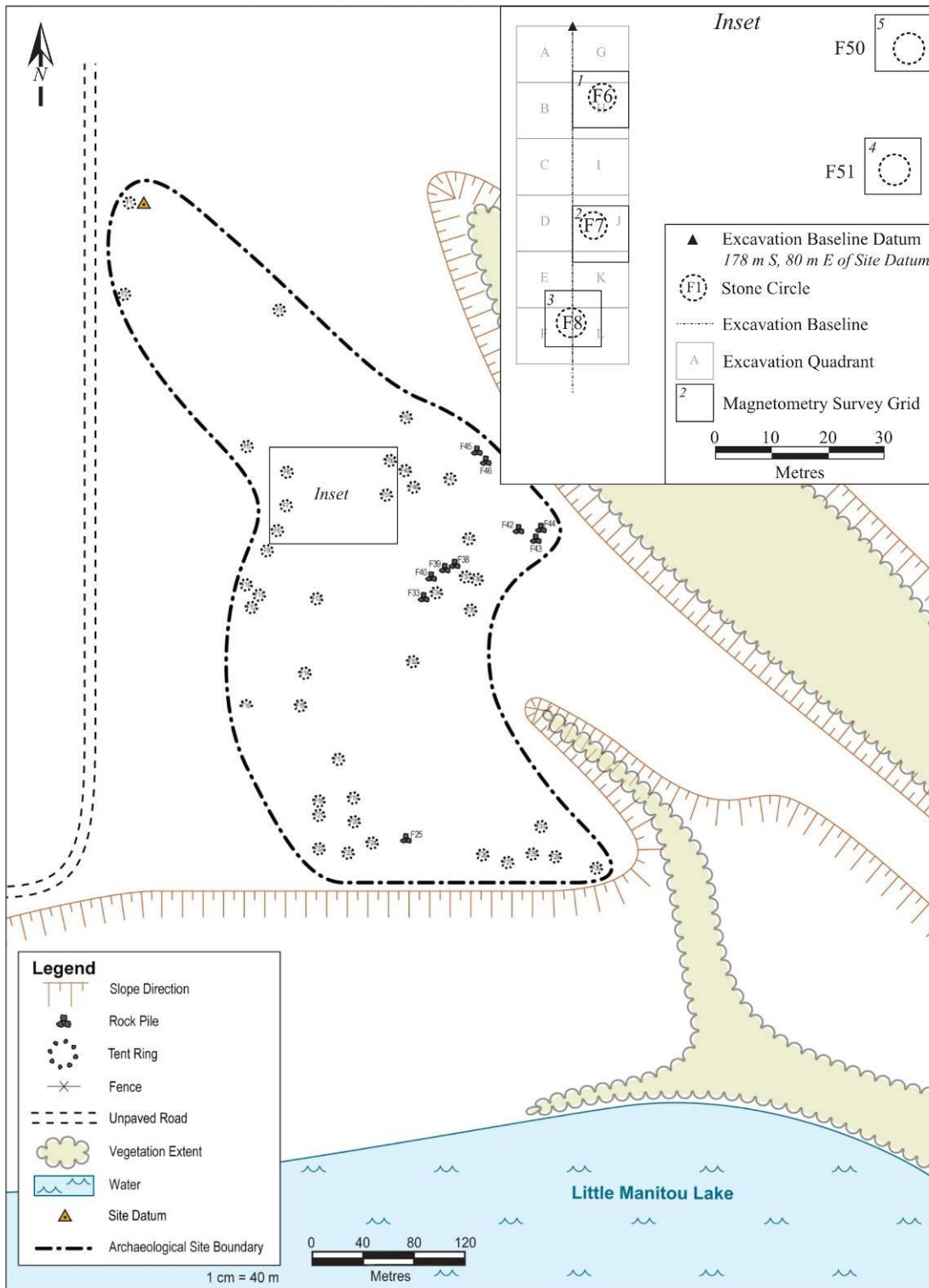


Figure A1-1. Focused area of investigation at EkNj-4 (primary map after Rescan 2011).

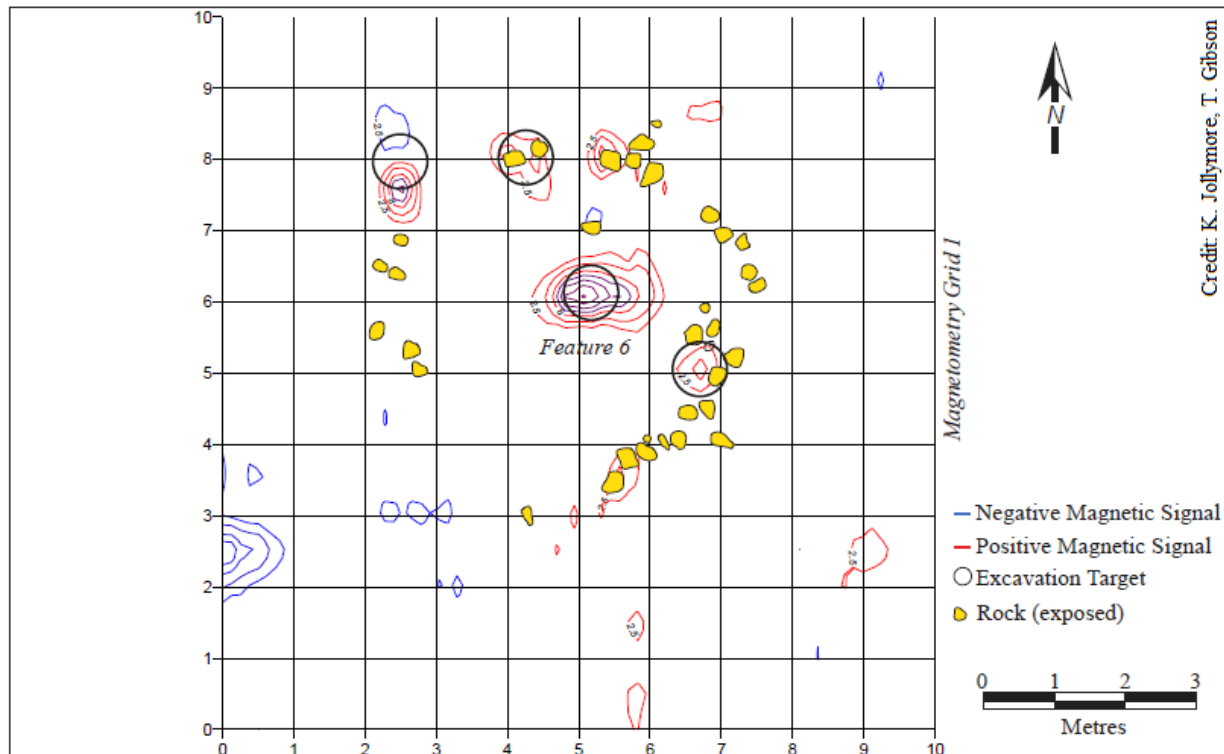


Figure A1-2. Results of magnetometry Grid 1 and mapped rocks for EkNj-4 Feature 6. Magnetic data shown in 1nT intervals, starting -2.5/2.5 nT.

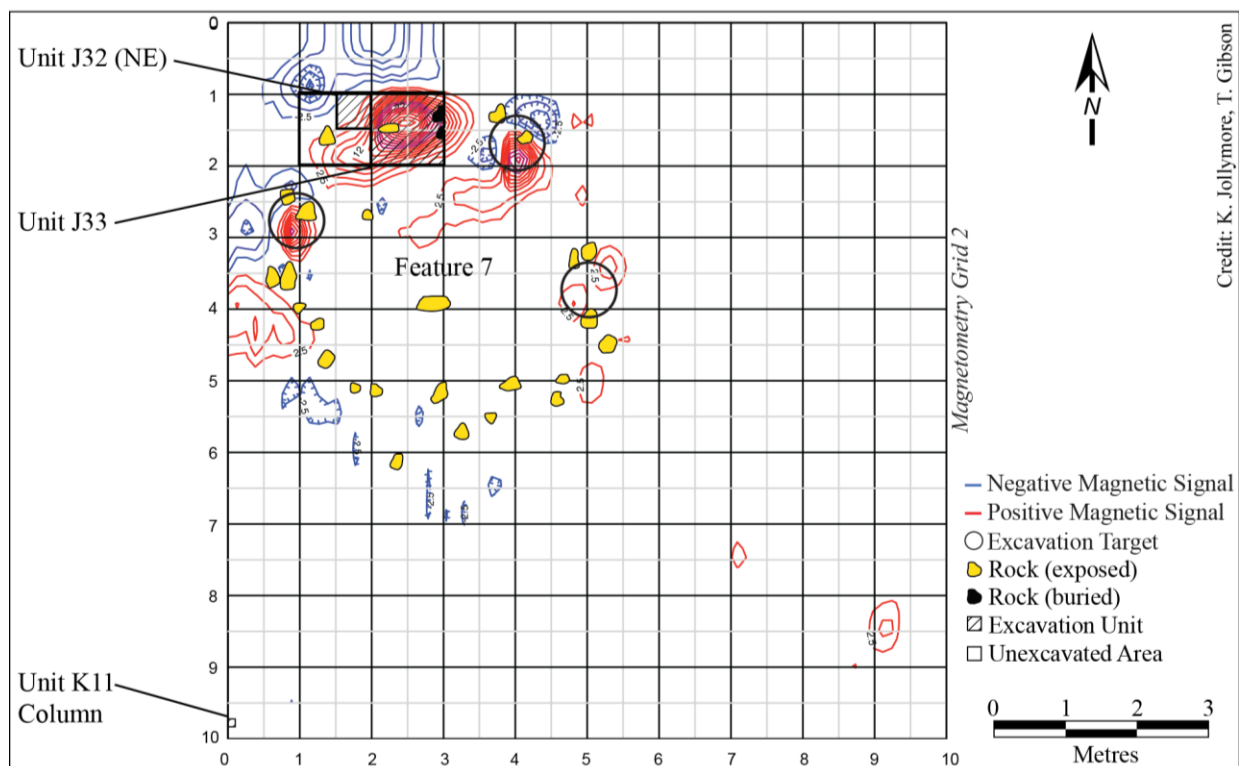


Figure A1-3. Results of magnetometry Grid 2, mapped rocks for EkNj-4 Feature 7, and excavation units J32 and J33. Magnetic data shown in 1nT intervals, starting -2.5/2.5 nT.

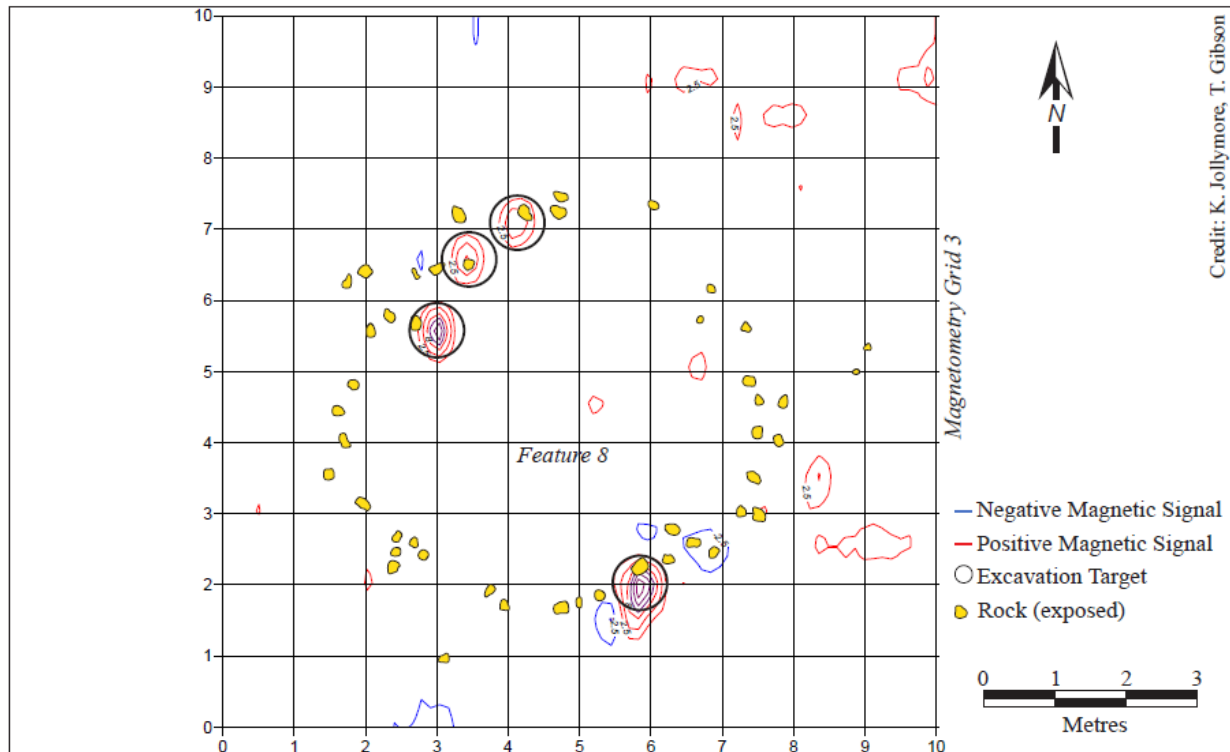


Figure A1-4. Results of magnetometry Grid 3 and mapped rocks for EkNj-4 Feature 8. Magnetic data shown in 1nT intervals, starting -2.5/2.5 nT.

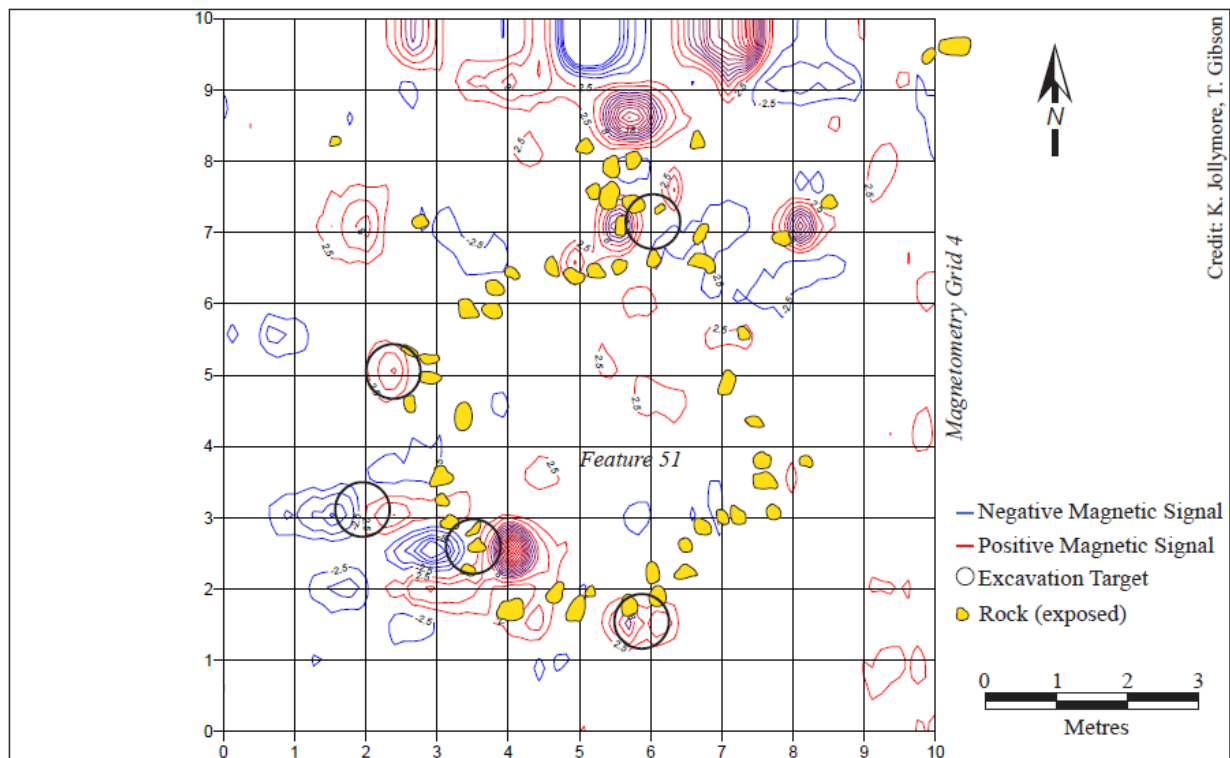
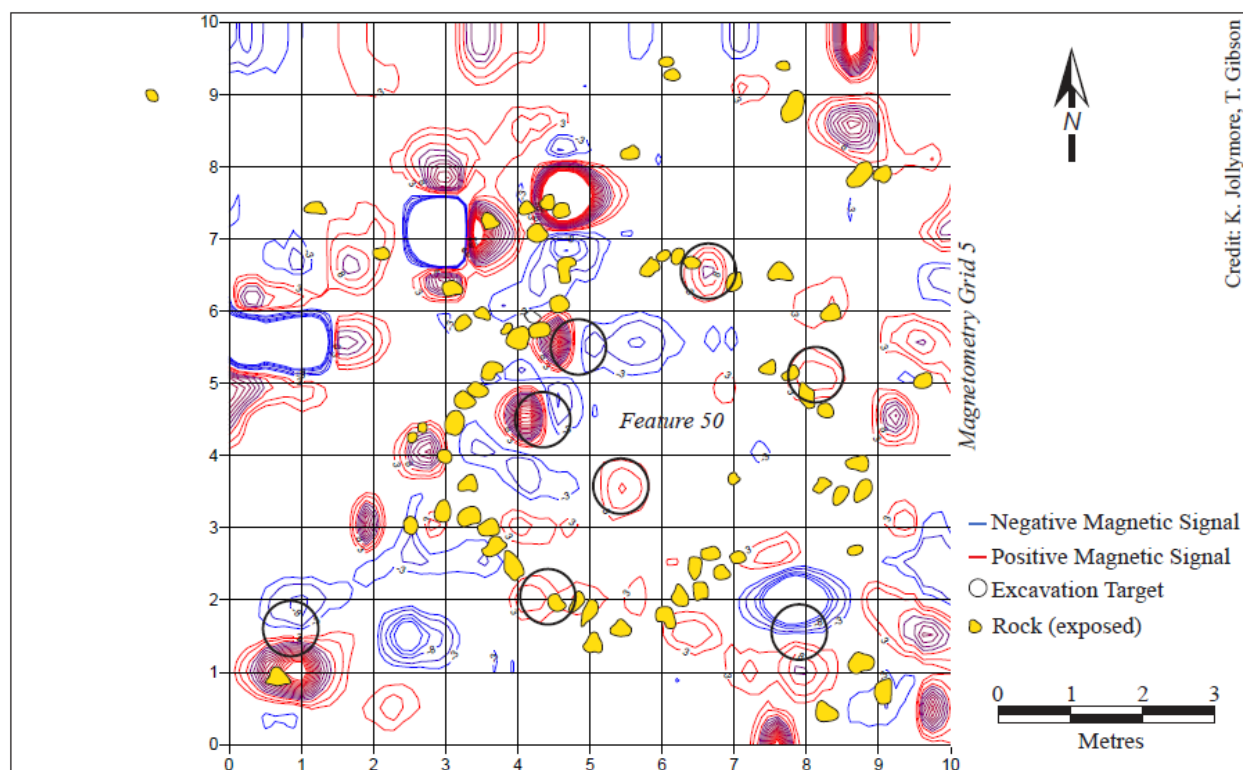


Figure A1-5. Results of magnetometry Grid 4, and mapped rocks for EkNj-4 Feature 51. Magnetic data shown in 1nT intervals, starting -2.5/2.5 nT.



Credit: K. Jollymore, T. Gibson

Figure A1-6. Results of magnetometry Grid 5 and mapped rocks for EkNj-4 Feature 50. Magnetic data shown in 1nT intervals, starting at -3/3 nT, with intervals beyond -10/10 nT suppressed.

A2. EkNj-68

211

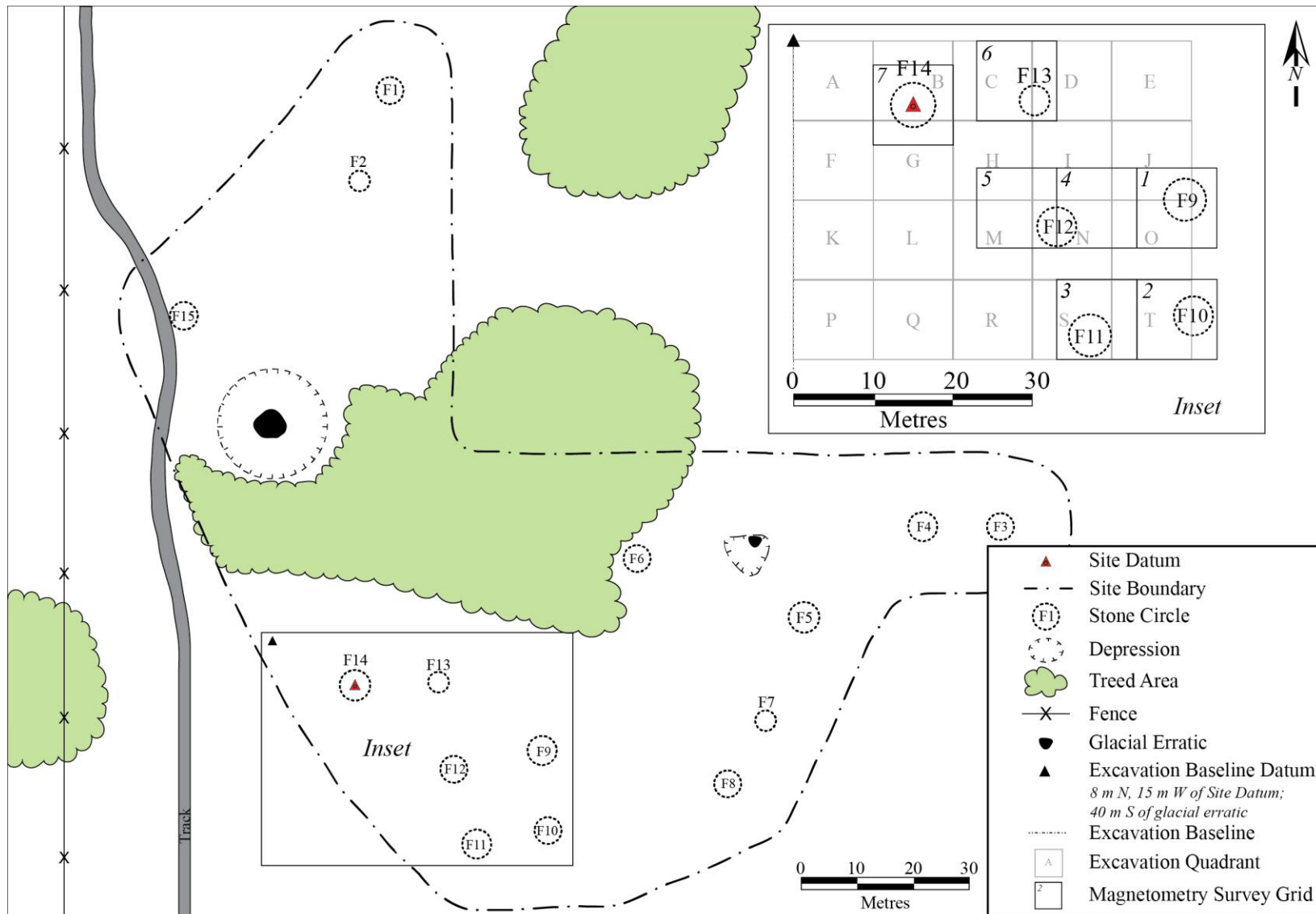


Figure A2-1. Site map of EkNj-68 with area of detailed investigation.

Table A2-1. Attribute data for stone circles at EkNj-68.

Feature Number	Feature Type	Diameter (m)	Rocks Per Ring	Rock Depth (buried estimate)	Door/Wall Gap Direction	Remarks
F1	Stone circle	5	38	Deeply	SE	Single wall.
F2	Stone circle	4	67	Deeply	SE	Pink rock in centre.
F3	Stone circle	5	40	Deeply	W, E, NE	Single loose wall. Rock pile on NW edge. Gopher hole in centre.
F4	Stone circle	5.5	39	Deeply	W, SE	Single loose wall.
F5	Stone circle	6	66	Deeply	S	Double wall. White rock in centre.
F6	Stone circle	5	46	Deeply		Single wall. White and pink rocks in centre at W edge.
F7	Stone circle	4	29	Deeply		Single wall. White rock on N of centre.
F8	Stone circle	5	38	Deeply	S	Single wall. Black and white rock on S side in centre.
F9	Stone circle	5.5	18	Deeply	NW, SW, E, S	Double wall. 2 rocks (pink, white) in middle.
F10	Stone circle	5	30	Deeply	NW, W, SW, SE	Double wall.
F11	Stone circle	5.5	78	Deeply	NW, SE, SW	Double wall.
F12	Stone circle	5	60	Deeply	NW, W	Double wall.
F13	Stone circle	4	45	Deeply	NW	Double wall (NE side only).
F14 (Datum)	Stone circle	6	61	Deeply	NW	Single wall.
F15	Stone circle	5	n/a	Deeply		Immediately adjacent (east) of track. Western edge likely disturbed. In very deep grass.

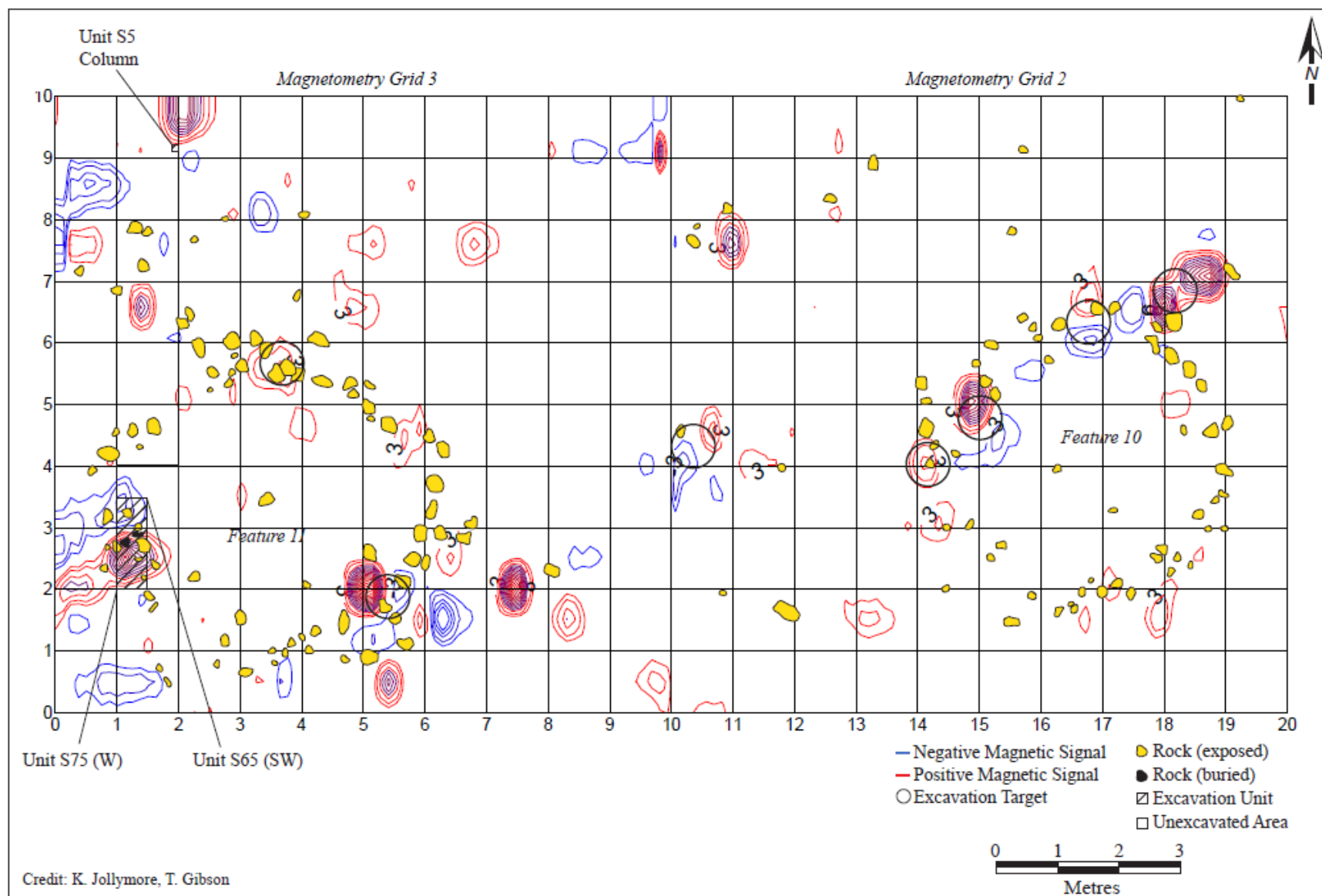


Figure A2-2. Results of magnetometry Grids 2 and 3, mapped rocks for EkNj-68 Features 10 and 11 and adjacent areas, column sample from unit S5, and excavation units S65 and S75. Magnetic data shown in 1nT intervals, starting at -3/3 nT.

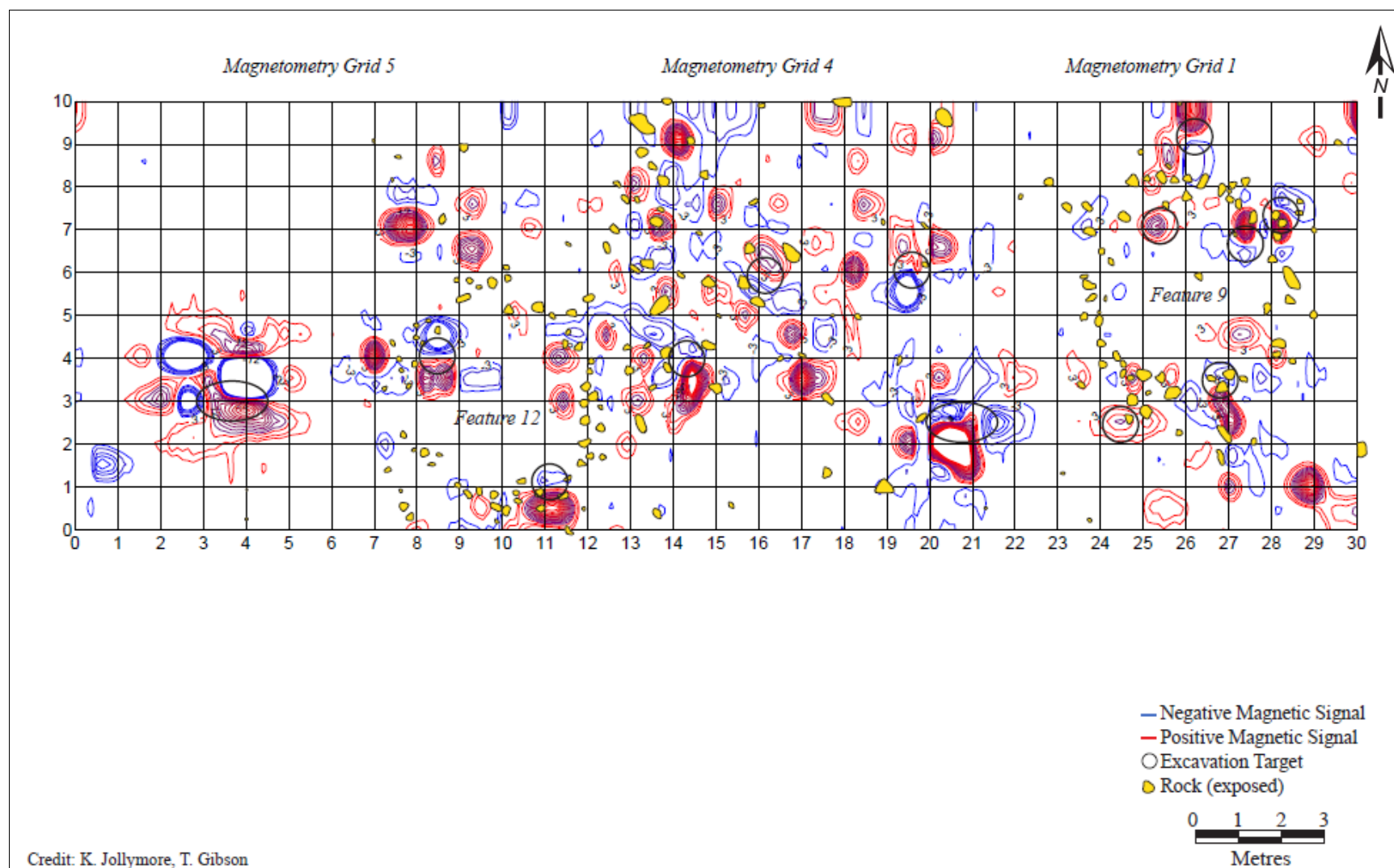


Figure A2-3. Results of magnetometry Grids 1, 4 and 5 and mapped rocks for EkNj-68 Features 9 and 12 and adjacent areas. Magnetic data shown in 1nT intervals, starting at -3/3 nT, with intervals beyond -10/10 nT suppressed.

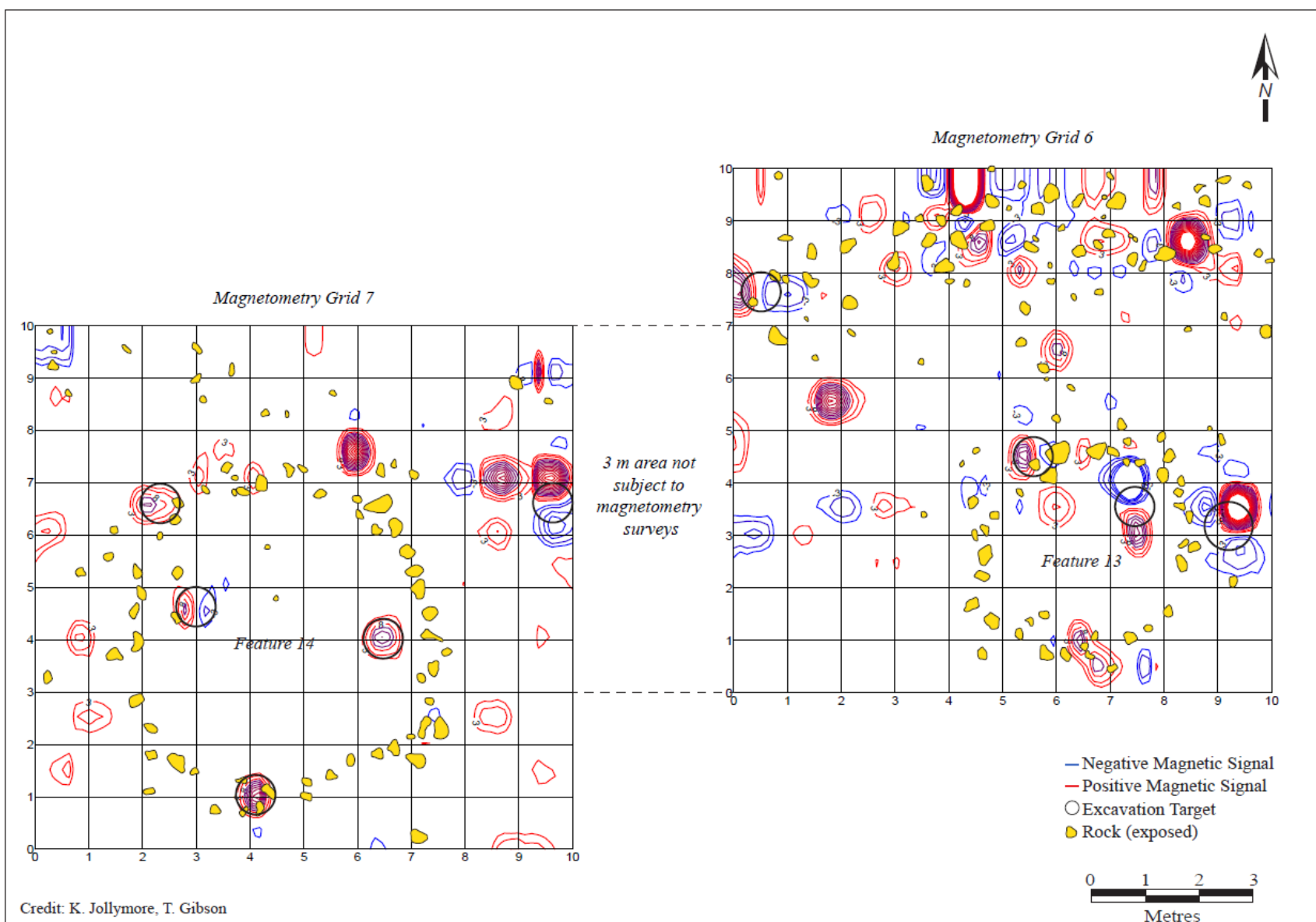


Figure A2-4. Results of magnetometry Grids 6 and 7 and mapped rocks for EkNj-68 Features 13 and 14 and adjacent areas. Magnetic data shown in 1nT intervals, starting at -3/3 nT, with intervals beyond -10/10 nT suppressed.

Excavation Baseline Datum
74 m S, 47 m W of Site Datum;
100 m E of SE corral post

Legend

- Excavation Baseline Datum
- Stone Circle
- Fence
- Excavation Baseline
- Excavation Quadrant
- Magnetometry Survey Grid

Inset

Creek

Carlin F11

Existing S.P.C. P.R.O.W.

F1

F2

F3

F4

F5

F6

F7

F8

F9

F10

F12

F13

F14

F15

Corral

Gate

Dirt Trail

Little Manitou Lake

0 20 40 60 Metres

0 10 20 30 Metres

1 cm = 20 m

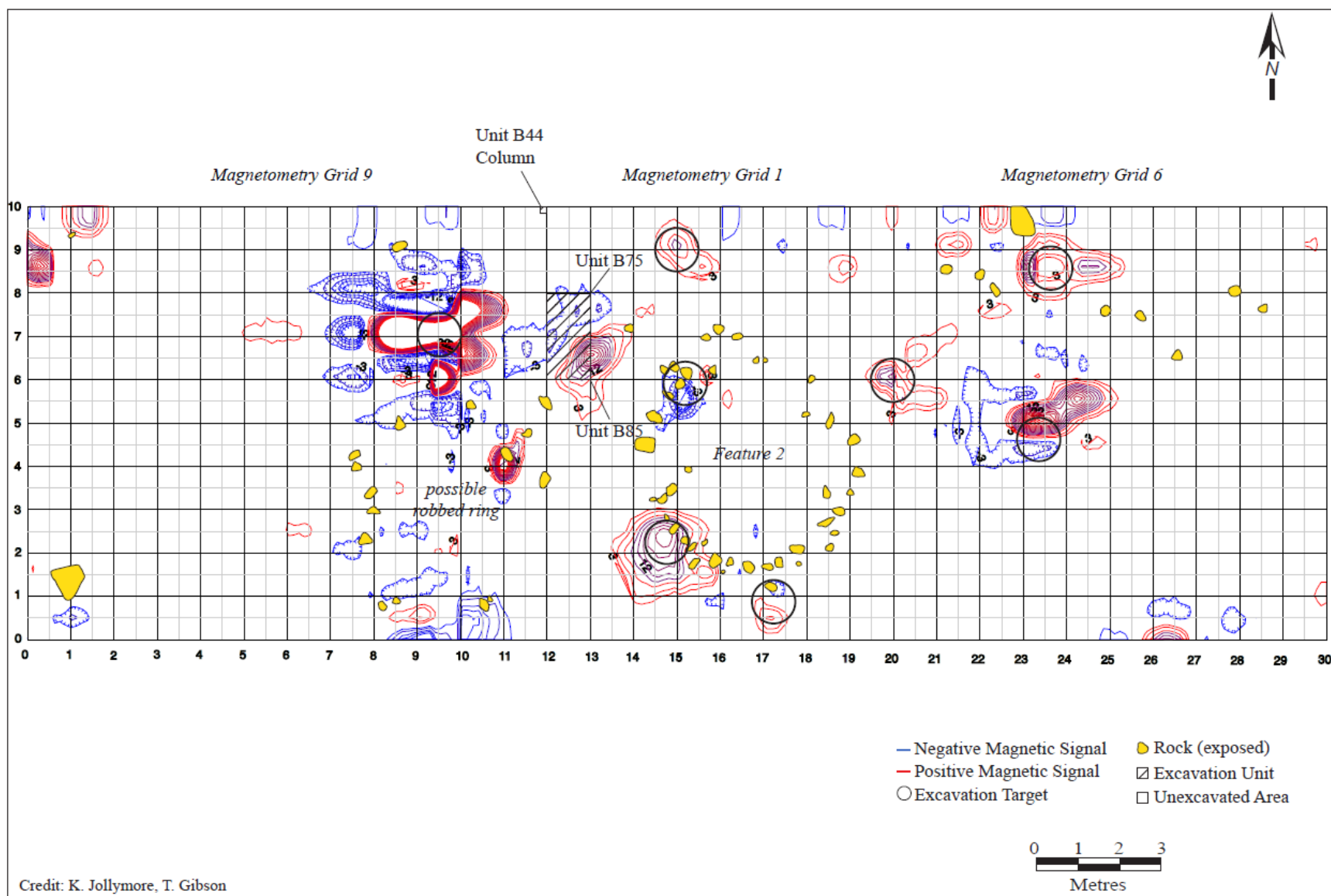


Figure A3-2. Results of magnetometry Grids 1, 6 and 9 and mapped rocks for EkNk-3 Feature 2 and adjacent areas, column sample from unit B44, and excavation units B75 and B85. Magnetic data shown in 1nT intervals, starting at -3/3 nT, with intervals beyond -10/10 nT suppressed.

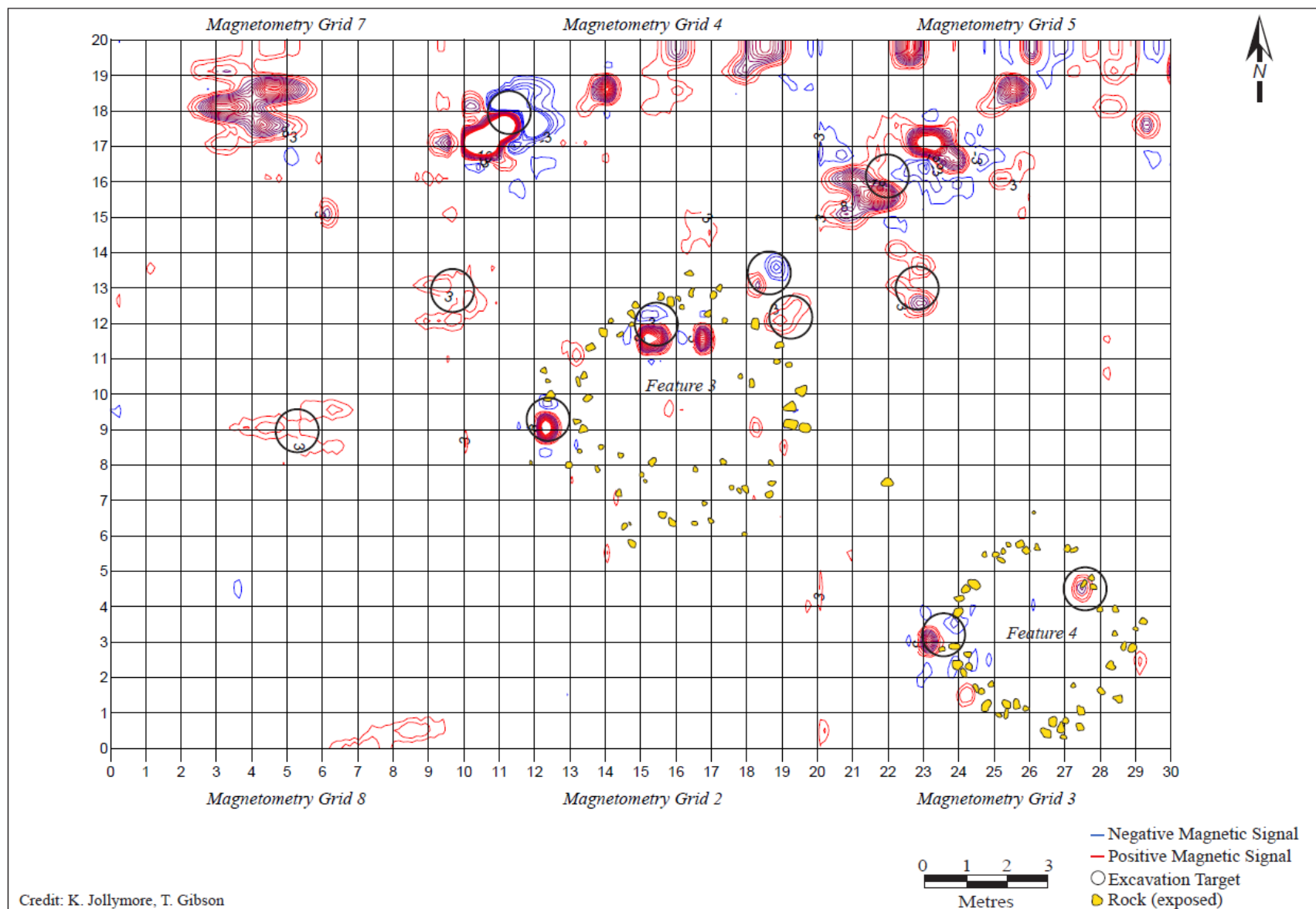


Figure A3-3. Results of magnetometry Grids 2, 3, 4, 5, 7 and 8 and mapped rocks for EkNk-3 Features 3 and 4 and adjacent areas. Magnetic data shown in 1nT intervals, starting at -3/3 nT, with intervals beyond -10/10 nT suppressed.

Appendix B

Artifact Catalogues and Debitage Analysis

This appendix presents artifact catalogues, artifact photographs, anddebitage analyses for material recovered during excavations at EkNj-4 (Section B1), EkNj-68 (Section B2), and EkNk-3 (Section B3).

B1. EkNj-4

The artifact catalogue for material recovered during excavations at EkNj-4 is presented in Table B1-1, lithic debitage analysis is presented in Table B1-2, and photographs of recovered artifacts are presented in Figures B1-1 to 6.

Table B1-1. Catalogue of materials recovered from EkNj-4.

Catalogue #	Evaluative Unit	Level	Quadrant	DBD (cm)	X - Coordinate (East) (cm)	Y - Coordinate (North) (cm)	Quantity	Artifact Type	Sub-Type	Material	Color	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Comments
EkNj-4:1	J32	1					1	Chipped Stone	Debitage	Quartzite	White	0.50	0.40	0.20	0.06	
EkNj-4:2	J32	2					1	Chipped Stone	Debitage	Quartzite	White	0.75	0.49	0.15	0.05	
EkNj-4:3	J32	3					1	Chipped Stone	Debitage	Chert	Beige	2.16	1.11	0.86	1.80	
EkNj-4:4	J32	South Wall	SE				1	Chipped Stone	Debitage	Chert	White	1.19	0.60	0.52	0.29	
EkNj-4:5	J33	1	NW	4	4	96	1	Chipped Stone	Retouched Flake	Swan River Chert	Grey	2.45	1.15	0.60	1.62	
EkNj-4:6	J33	2	NE	8	54	93	1	Hammerstone	Pebble	Quartzite	Green	2.97	2.17	1.27	10.88	
EkNj-4:7	J33	2	NW	10	43	100	1	Pigment		Ochre	Orange	1.04	0.69	0.61	0.20	
EkNj-4:8	J33	2	NW	9	4	78	1	Polishing stone	Cobble	Fine-grained Quartzite	Grey	8.30	7.09	3.51	285.58	Do not wash. Potential for future residue analysis.
EkNj-4:9	J33	2					1	Chipped Stone	Debitage	Swan River Chert	Grey	0.78	0.54	0.20	0.08	
EkNj-4:10	J33	2					1	Chipped Stone	Debitage	Swan River Chert	Grey	0.38	0.39	0.13	0.02	

Continued

Table B1-1. Catalogue of materials recovered from EkNj-4 (completed).

Catalogue #	Evaluative Unit	Level	Quadrant	DBD (cm)	X - Coordinate (East) (cm)	Y - Coordinate (North) (cm)	Quantity	Artifact Type	Sub-Type	Material	Color	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Comments
EkNj-4:11	J33	2	NW	8-9	0-30	50-100	1	Chipped Stone	Debitage	Quartzite	Brown	0.37	0.34	0.10	0.01	Recovered from heavy fraction of matrix sample 2.
EkNj-4:12	J33	2	NW	6	34	56	1	Faunal	Large Mammal	Bone		5.45	2.20	1.25	7.88	Long bone shaft fragment. Element likely tibia. Recovered at base of tipi rock 1.
EkNj-4:13	J33	2	NW	8	22	63	1	Faunal	Unidentifiable fragment	Bone		2.25	1.20	0.60	1.13	
EkNj-4:14	J33	2					1	Faunal	Unidentifiable fragment	Bone		2.40	0.95	0.30	0.54	Recovered in screen.
EkNj-4:15	J33	3					1	Ammunition	Shot	Lead	Brown			0.29	0.03	#6 shot (0.11 inches)
EkNj-4:16	J33	3					1	Chipped Stone	Debitage	Quartzite	White	0.71	0.47	0.14	0.05	
EkNj-4:17	J33	3	NW	10-12	0-25	50-100	1	Chipped Stone	Debitage	Chert	White	0.27	0.18	0.05	0.01	Recovered from heavy fraction of matrix sample 3.
EkNj-4:18	J33	3	NW	10-12	0-25	50-100	1	Chipped Stone	Debitage	Chert	White	0.30	0.18	0.03	0.01	Recovered from heavy fraction of matrix sample 3.

Table B1-2. Debitage analysis for lithic materials recovered from EkNj-4.

Catalogue #	Unit	Level	Raw Material	Completeness					Flake Type						Size Category (cm)					Weight (g)
				Complete Flake	Broken Flake	Fragment Flake	Debris	Split	Biface Thinning	Hard Hammer / Core Reduction	Pressure / Finishing	Bipolar	Cortical	Interior	<0.1	0.1-0.25	0.25-0.5	0.5-1.0	>1.0	
EkNj-4:1	J32	1	Quartzite				1			1				1			1			0.06
EkNj-4:2	J32	2	Quartzite	1							1			1				1		0.05
EkNj-4:3	J32	3	Chert				1			1				1					1	1.80
EkNj-4:4	J32	South wall	Chert				1			1				1					1	0.29
EkNj-4:9	J33	2	Swan River Chert	1							1			1				1		0.08
EkNj-4:10	J33	2	Swan River Chert		1						1			1			1			0.02
EkNj-4:11	J33	2	Quartzite	1							1			1			1			0.01
EkNj-4:17	J33	3	Chert	1							1			1			1			0.01
EkNj-4:18	J33	3	Chert				1				1			1			1			0.01
Total				4	1	0	4	0	0	3	6	0	0	9	0	0	5	2	2	2.33



Figure B1-1. Retouched flake EkNj-4:5 of Swan River chert recovered from Level 1, Unit J33.



Figure B1-2. Pebble hammerstone EkNj-4:6 recovered from Level 2, Unit J33. Evidence of pecking at narrow end and potential residue/staining.



Figure B1-3. Ochre pigment EkNj-4:7 recovered from Level 2, Unit J33.

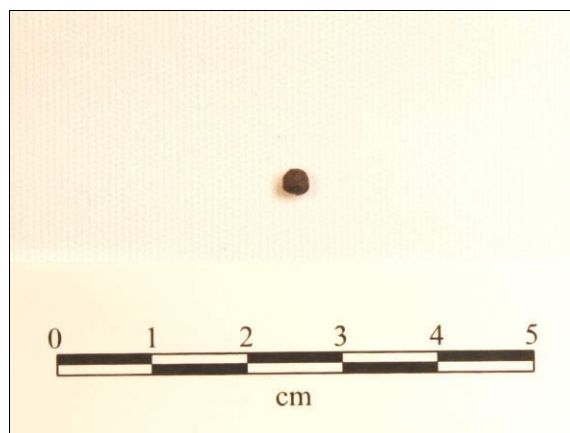


Figure B1-4. No. 6 lead birdshot pellet EkNj-4:15 recovered from Level 3, Unit J33.



Figure B1-5. Polishing stone EkNj-4:8, with evidence of blackening on one side (image right) recovered from Level 2, Unit J33.



Figure B1-6. Faunal fragments from large ungulate (likely bison). L-R: EkNj-4:12-14, recovered from Level 2, Unit J33.

B2. EkNj-68

The artifact catalogue for material recovered during excavations at EkNj-68 is presented in Table B2-1, lithic debitage analysis is presented in Table B2-2, and photographs of recovered artifacts are presented in Figures B2-1 to 3.

Table B2-1. Catalogue of materials recovered from EkNj-68.

Catalogue #	Evaluative Unit	Level	Quadrant	DBD (cm)	X - Coordinate (East) (cm)	Y - Coordinate (North) (cm)	Quantity	Artifact Type	Sub-Type	Material	Color	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Comments
EkNj-68:1	S65	1					1	Chipped stone	Debitage	Chert	Beige	0.98	0.84	0.55	0.48	
EkNj-68:2	S65	1					1	Chipped stone	Debitage	Chert	Brown	1.01	0.59	0.44	0.30	
EkNj-68:3	S65	1					1	Chipped stone	Debitage	Chert	White	0.94	0.63	0.43	0.22	
EkNj-68:4	S65	1					1	Chipped stone	Debitage	Chert	White	0.56	0.40	0.18	0.04	
EkNj-68:5	S65	1					1	Chipped stone	Debitage	Chert	Grey	0.46	0.48	0.38	0.09	
EkNj-68:6	S65	1					1	Chipped stone	Debitage	Chert	Grey	0.60	0.30	0.25	0.04	
EkNj-68:7	S65	1					1	Chipped stone	Debitage	Quartzite	Clear	0.77	0.59	0.37	0.18	
EkNj-68:8	S65	1					1	Chipped stone	Debitage	Quartzite	Clear	0.64	0.54	0.20	0.06	
EkNj-68:9	S65	4					1	Chipped stone	Debitage	Quartzite	White	0.54	0.37	0.32	0.08	Likely from south wall.
EkNj-68:10	S65	4					1	Chipped stone	Debitage	Quartzite	White	0.56	0.33	0.15	0.02	Likely from south wall.
EkNj-68:11	S75	1					1	Chipped stone	Debitage	Chert	Beige	0.46	0.38	0.12	0.02	
EkNj-68:12	S75	2					1	Chipped stone	Debitage	Chert	Beige	0.60	0.70	0.43	0.20	
EkNj-68:13	S75	2					1	Chipped stone	Debitage	Chert	White	0.63	0.58	0.25	0.08	
EkNj-68:14	S75	2					1	Chipped stone	Debitage	Chert	Brown	0.53	0.39	0.18	0.04	

Continued

Table B2-1. Catalogue of materials recovered from EkNj-68 (completed).

Catalogue #	Evaluative Unit	Level	Quadrant	DBD (cm)	X - Coordinate (East) (cm)	Y - Coordinate (North) (cm)	Quantity	Artifact Type	Sub-Type	Material	Color	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Comments
EkNj-68:15	S75	2					1	Chipped stone	Utilized Flake	Swan River Chert	Grey	1.75	1.02	0.51	1.05	Do not wash. Potential for future residue analysis.
EkNj-68:16	S75	3		16	26	64	1	Chipped stone	Debitage	Quartz	Clear	0.60	0.65	0.25	0.10	
EkNj-68:17	S75	3		16	19	64	1	Polishing stone	Pebble	Granite	Black	2.65	2.17	1.42	13.76	
EkNj-68:18	S75	3		16.5	36	18	1	Hammerstone	Cobble	Quartzite	Pink	5.62	5.02	2.25	96.61	
EkNj-68:19	S75	3		19.5	21	37	1	Pigment		Ochre	Brown	1.27	1.07	0.83	1.03	
EkNj-68:20	S75	4					1	Chipped stone	Retouched Flake	Swan River Chert	Grey				1.08	

Table B2-2. Debitage analysis for lithic materials recovered from EkNj-68.

Catalogue #	Unit	Level	Raw Material	Completeness					Flake Type						Size Category (cm)					Weight (g)
				Complete Flake	Broken Flake	Fragment Flake	Debris	Split	Biface Thinning	Hard Hammer / Core Reduction	Pressure / Finishing	Bipolar	Cortical	Interior	<0.1	0.1-0.25	0.25-0.5	0.5-1.0	>1.0	
EkNj-68:1	S65	1	Chert	1						1			1					1		0.48
EkNj-68:2	S65	1	Chert				1			1				1					1	0.30
EkNj-68:3	S65	1	Chert				1			1				1				1		0.22
EkNj-68:4	S65	1	Chert				1			1				1				1		0.04
EkNj-68:5	S65	1	Chert				1			1				1			1			0.09
EkNj-68:6	S65	1	Chert				1			1				1				1		0.04
EkNj-68:7	S65	1	Quartzite				1			1				1				1		0.18
EkNj-68:8	S65	1	Quartzite	1							1			1				1		0.06
EkNj-68:9	S65	4	Quartzite		1					1			1					1		0.08
EkNj-68:10	S65	4	Quartzite	1							1			1				1		0.02
EkNj-68:11	S75	1	Chert		1						1			1			1			0.02
EkNj-68:12	S75	2	Chert				1			1			1					1		0.20
EkNj-68:13	S75	2	Chert		1					1				1				1		0.08
EkNj-68:14	S75	2	Chert		1					1				1				1		0.04
EkNj-68:16	S75	3	Quartz	1							1			1				1		0.10
Total				3	5	0	7	0	0	11	4	0	3	12	0	0	2	12	1	1.95



Figure B2-1. Utilized and retouched flakes (L to R: EkNj-68:15, 20), both of Swan River chert. Utilized flake recovered from Level 2, UnitS75; retouched flake recovered from Level 4, Unit S75.



Figure B2-2. Pebble polishing stone and cobble hammerstone (L to R: EkNj-68:17, 18), both recovered from Level 3, UnitS75. Potential residue/staining on EkNj-68:17. Evidence of pecking at narrow end of EkNj-68:18.



Figure B2-3. Ochre pigment EkNj-68:19 recovered from Level 3, UnitS75.

B3. EkNk-3

The artifact catalogue for material recovered during excavations at EkNk-3 is presented in Table B3-1, lithic debitage analysis is presented in Table B3-2, and photographs of recovered artifacts are presented in Figures B3-1 to 6.

Table B3-1. Catalogue of materials recovered from EkNk-3.

Catalogue #	Evaluative Unit		Level	Quadrant	DBD (cm)	X - Coordinate (East) (cm)	Y - Coordinate (North) (cm)	Quantity	Artifact Type	Sub-Type	Material	Color	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Comments
EkNk-3:1	B75	1	NW					1	Chipped stone	Debitage	Swan River Chert	Grey	0.50	0.75	0.25	0.12	
EkNk-3:2	B75	1	NW					1	Chipped stone	Retouched Flake	Swan River Chert	Beige	0.90	1.20	0.55	0.81	
EkNk-3:3	B75	1	NW					1	Chipped stone	Debitage	Quartzite	Grey	0.55	0.90	0.20	0.10	
EkNk-3:4	B75	1	NW					1	Chipped stone	Debitage	Chert	Beige	0.70	0.75	0.30	0.19	
EkNk-3:5	B75	1	NW					1	Chipped stone	Debitage	Quartzite	White	0.70	0.50	0.30	0.07	
EkNk-3:6	B75	2						1	Chipped stone	Debitage	Fine-grained Quartzite	Brown	1.05	1.00	0.30	0.21	
EkNk-3:7	B75	2						1	Chipped stone	Debitage	Quartzite	Pink	1.60	1.05	0.40	0.64	
EkNk-3:8	B75	2						1	Chipped stone	Debitage	Quartzite	Pink	1.10	1.00	0.35	0.29	
EkNk-3:9	B75	2						1	Chipped stone	Debitage	Quartzite	White	0.40	0.55	0.15	0.04	
EkNk-3:10	B75	2	NE					1	Chipped stone	Debitage	Fine-grained Quartzite	Brown	0.25	0.30	0.15	0.01	Recovered from heavy fraction of matrix sample 10.
EkNk-3:11	B75	2	NE					1	Chipped stone	Debitage	Quartzite	White	0.25	0.25	0.05	0.01	Recovered from heavy fraction of matrix sample 10.

Continued

Table B3-1. Catalogue of materials recovered from EkNk-3 (continued).

Catalogue #	Evaluative Unit	Level	Quadrant	DBD (cm)	X - Coordinate (East) (cm)	Y - Coordinate (North) (cm)	Quantity	Artifact Type	Sub-Type	Material	Color	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Comments
EkNk-3:12	B75	2	NE				1	Chipped stone	Debitage	Quartzite	White	0.15	0.15	0.05	0.01	Recovered from heavy fraction of matrix sample 10.
EkNk-3:13	B75	3					1	Chipped stone	Debitage	Quartzite	Beige	0.80	0.50	0.20	0.07	
EkNk-3:14	B75	4	SE				1	Shell	<i>Stagnicola caperata</i>	Shell	White	0.80		0.30	0.02	
EkNk-3:15	B75	4	SE				10	Shell	<i>Valvata tricarinata</i>	Shell	White	0.50		0.25	0.24	Average size recorded in catalogue.
EkNk-3:16	B75	4	NE				1	Shell	<i>Gyraulus parvus</i>	Shell	White	0.40		0.10	0.01	
EkNk-3:17	B75	4	NE				2	Shell	<i>Valvata tricarinata</i>	Shell	White	0.45		0.30	0.60	Average size recorded in catalogue.
EkNk-3:18	B75	4	NW				1	Shell	<i>Valvata tricarinata</i>	Shell	White	0.45		0.30	0.03	
EkNk-3:19	B75	5	NW				1	Shell	<i>Valvata tricarinata</i>	Shell	White	0.45		0.30	0.03	
EkNk-3:20	B75	5	NE				11	Shell	Fragments	Shell	White	0.30		0.20	0.02	Recovered from heavy fraction of matrix sample 9. Average size recorded in catalogue.
EkNk-3:21	B85	1					1	Ammunition	Shot	Lead	Grey			0.33	0.18	#4 shot (0.13 inches)
EkNk-3:22	B85	1					1	Ammunition	Shot	Lead	Grey			0.39	0.33	#2 shot (0.15 inches)
EkNk-3:23	B85	1	NE				1	Chipped stone	Debitage	Chert	Grey	0.60	0.45	0.05	0.03	
EkNk-3:24	B85	1	NE				1	Chipped stone	Debitage	Chert	Grey	0.55	0.55	0.10	0.03	
EkNk-3:25	B85	1	NE				1	Chipped stone	Debitage	Chert	Pink	0.50	0.40	0.30	0.04	
EkNk-3:26	B85	1	NE				1	Chipped stone	Debitage	Chert	Beige	1.10	0.45	0.25	0.14	
EkNk-3:27	B85	1	NE				1	Chipped stone	Debitage	Quartzite	Clear	0.60	0.50	0.40	0.15	
EkNk-3:28	B85	1	NE				1	Chipped stone	Debitage	Quartzite	White	0.75	0.45	0.15	0.06	

Continued

Table B3-1. Catalogue of materials recovered from EkNk-3 (continued).

Catalogue #	Evaluative Unit	Level	Quadrant	DBD (cm)	X - Coordinate (East) (cm)	Y - Coordinate (North) (cm)	Quantity	Artifact Type	Sub-Type	Material	Color	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Comments
EkNk-3:29	B85	1	NE	4.5	66	57	1	Chipped stone	Utilized Flake	Quartzite	Beige	3.20	1.80	1.20	4.63	Secondary decordication.
EkNk-3:30	B85	2	SW	8	27	30	1	Chipped stone	Debitage	Quartzite	Pink	1.70	0.90	0.50	0.86	
EkNk-3:31	B85	2	NE	9	72	90	1	Chipped stone	Debitage	Quartzite	White	0.75	1.00	0.30	0.25	
EkNk-3:32	B85	2					1	Chipped stone	Debitage	Siltstone	Grey	1.00	0.55	0.01	0.05	
EkNk-3:33	B85	2					1	Chipped stone	Debitage	Siltstone	Grey	0.70	0.75	0.01	0.08	
EkNk-3:34	B85	2					1	Chipped stone	Debitage	Chert	Grey	0.40	0.35	0.30	0.05	
EkNk-3:35	B85	2					1	Chipped stone	Debitage	Chert	Grey	1.05	0.50	0.30	0.11	
EkNk-3:36	B85	2					1	Chipped stone	Debitage	Chert	White	0.60	0.50	0.10	0.04	
EkNk-3:37	B85	2					1	Chipped stone	Debitage	Fine-grained Quartzite	Beige	0.60	0.40	0.20	0.04	
EkNk-3:38	B85	2					1	Chipped stone	Debitage	Fine-grained Quartzite	Beige	0.55	0.55	0.20	0.07	
EkNk-3:39	B85	2					1	Chipped stone	Debitage	Fine-grained Quartzite	Brown	0.55	0.55	0.20	0.07	
EkNk-3:40	B85	2					1	Chipped stone	Debitage	Fine-grained Quartzite	Brown	0.95	0.40	0.35	0.16	
EkNk-3:41	B85	2					1	Chipped stone	Debitage	Quartzite	White	0.85	0.75	0.10	0.11	
EkNk-3:42	B85	2					1	Chipped stone	Debitage	Quartzite	White	0.45	0.45	0.10	0.03	
EkNk-3:43	B85	2					1	Chipped stone	Debitage	Quartz	Clear	0.70	0.45	0.25	0.08	
EkNk-3:44	B85	2		9	84	58	1	Faunal	<i>Bison</i> sp.	Bone		3.50	3.05	2.85	15.37	Right-side internal carpal. Likely female.
EkNk-3:45	B85	3					1	Chipped stone	Debitage	Quartz	Clear	0.70	0.70	0.40	0.24	Evidence of microwear on one edge.

Continued

Table B3-1. Catalogue of materials recovered from EkNk-3 (completed).

Catalogue #	Evaluative Unit	Level	Quadrant	DBD (cm)	X - Coordinate (East) (cm)	Y - Coordinate (North) (cm)	Quantity	Artifact Type	Sub-Type	Material	Color	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Comments
EkNk-3:46	B85	3		10	15	86	1	Pigment		Talc	White	2.40	2.25	1.60	14.84	Recovered from heavy fraction of matrix sample 11.
EkNk-3:47	B85	3		12	48	8	1	Polishing stone	Pebble	Quartzite	Beige	4.30	3.00	2.40	40.87	
EkNk-3:48	B85	3					36	Shell	<i>Valvata tricarinata</i>	Shell	White	0.50		0.25	0.44	
EkNk-3:49	B85	3					22	Shell	<i>Stagnicola caperata</i>	Shell	White	0.80		0.30	0.10	
EkNk-3:50	B85	3					8	Shell	<i>Gyraulus parvus</i>	Shell	White	0.40		0.10	0.07	
EkNk-3:51	B85	4	NE				180	Shell	<i>Valvata tricarinata</i>	Shell	White	0.45		0.30	4.84	
EkNk-3:52	B85	4	NE				105	Shell	<i>Stagnicola caperata</i>	Shell	White	0.80		0.30	2.53	
EkNk-3:53	B85	4	NE				25	Shell	<i>Gyraulus parvus</i>	Shell	White	0.40		0.10	0.36	
EkNk-3:54	B85	4					24	Shell	<i>Valvata tricarinata</i>	Shell	White	0.80		0.30	0.15	
EkNk-3:55	B85	4					8	Shell	<i>Stagnicola caperata</i>	Shell	White	0.45		0.30	0.48	
EkNk-3:56	B85	4					3	Shell	<i>Gyraulus parvus</i>	Shell	White	0.40		0.10	0.04	

Table B3-2. Debitage analysis for lithic materials recovered from EkNk-3.

Catalogue #	Unit	Level	Raw Material	Completeness					Flake Type						Size Category (cm)					Weight (g)
				Complete Flake	Broken Flake	Fragment Flake	Debris	Split	Biface Thinning	Hard Hammer / Core Reduction	Pressure / Finishing	Bipolar	Cortical	Interior	<0.1	0.1-0.25	0.25-0.5	0.5-1.0	>1.0	
EkNk-3:1	B75	1	Swan River Chert				1			1				1				1		0.12
EkNk-3:3	B75	1	Quartzite				1			1				1				1		0.10
EkNk-3:4	B75	1	Chert				1			1				1				1		0.19
EkNk-3:5	B75	1	Quartzite				1			1				1				1		0.07
EkNk-3:6	B75	2	Fine-grained Quartzite	1					1					1					1	0.21
EkNk-3:7	B75	2	Quartzite		1				1					1					1	0.64
EkNk-3:8	B75	2	Quartzite		1				1					1					1	0.29
EkNk-3:9	B75	2	Quartzite		1						1			1				1		0.04
EkNk-3:10	B75	2	Fine-grained Quartzite				1							1			1			0.01
EkNk-3:11	B75	2	Quartzite				1							1			1			0.01
EkNk-3:12	B75	2	Quartzite				1							1		1				0.01
EkNk-3:13	B75	3	Quartzite		1				1				1					1		0.07
EkNk-3:23	B85	1	Chert				1							1				1		0.03
EkNk-3:24	B85	1	Chert		1				1					1				1		0.03
EkNk-3:25	B85	1	Chert				1			1			1					1		0.04
EkNk-3:26	B85	1	Chert	1							1			1					1	0.14
EkNk-3:27	B85	1	Quartzite				1			1				1				1		0.15
EkNk-3:28	B85	1	Quartzite					1			1			1				1		0.06

Continued to next page.

Table B3-2. Debitage analysis for lithic materials recovered from EkNk-3 (completed).

Catalogue #	Unit	Level	Raw Material	Completeness					Flake Type					Size Category (cm)					Weight (g)	
				Complete Flake	Broken Flake	Fragment Flake	Debris	Split	Biface Thinning	Hard Hammer / Core Reduction	Pressure / Finishing	Bipolar	Cortical	Interior	<0.1	0.1-0.25	0.25-0.5	0.5-1.0		>1.0
EkNk-3:30	B85	2	Quartzite				1			1			1						1	0.86
EkNk-3:31	B85	2	Quartzite		1					1				1					1	0.25
EkNk-3:32	B85	2	Siltstone	1						1					1				1	0.05
EkNk-3:33	B85	2	Siltstone		1					1					1					0.08
EkNk-3:34	B85	2	Chert				1				1					1				0.05
EkNk-3:35	B85	2	Chert	1								1							1	0.11
EkNk-3:36	B85	2	Chert		1					1				1				1		0.04
EkNk-3:37	B85	2	Fine-grained Quartzite				1					1						1		0.04
EkNk-3:38	B85	2	Fine-grained Quartzite				1				1							1		0.07
EkNk-3:39	B85	2	Fine-grained Quartzite				1				1							1		0.07
EkNk-3:40	B85	2	Fine-grained Quartzite				1				1							1		0.16
EkNk-3:41	B85	2	Quartzite	1						1								1		0.11
EkNk-3:42	B85	2	Quartzite	1						1						1				0.03
EkNk-3:43	B85	2	Quartz				1				1							1		0.08
EkNk-3:45	B85	3	Quartz		1							1						1		0.24
Total				6	9	0	17	1	11	12	6	0	6	27	0	1	4	20	8	4.45



Figure B3-1. Retouched and utilized flakes (L to R: EkNk-3:2, 29). Retouched flake of Swan River chert; utilized flake of quartzite. Both recovered from Level 1, Unit B75.

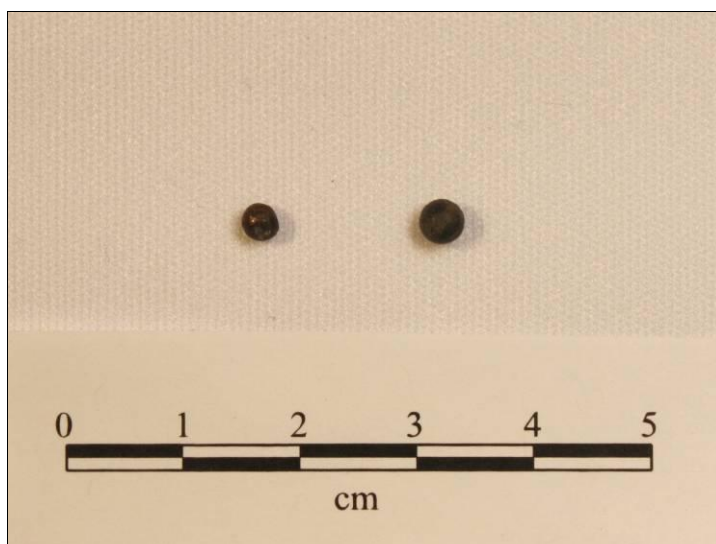


Figure B3-2. No. 4 and No. 2 lead birdshot pellets (L-R: EkNk-3:21, 22). Recovered from Level 1 (sod), Unit B85.

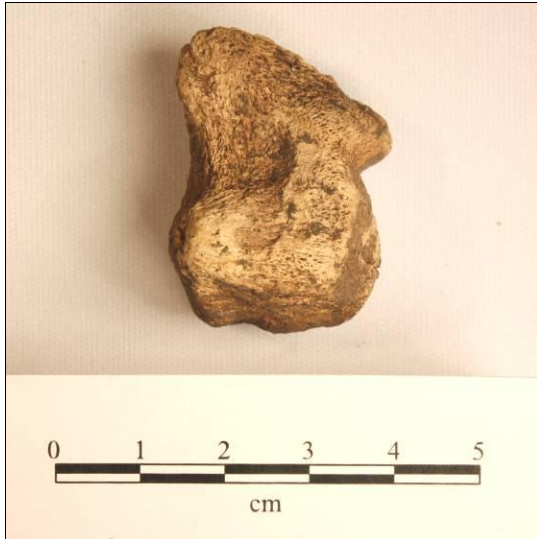


Figure B3-3. Gracile right-side internal carpal of *Bison* sp. EkNk-3:44 recovered from Level 2, Unit B85.



Figure B3-4. Talc pigment EkNk-3:46 recovered from Level 3, Unit B85.

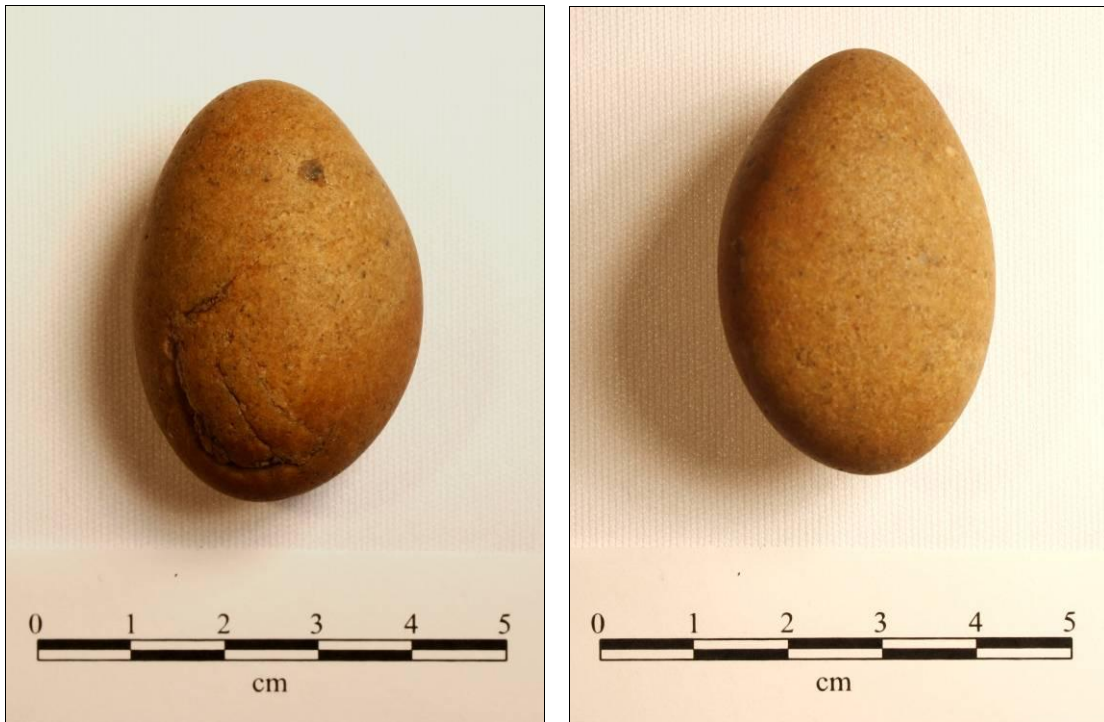


Figure B3-5. Pebble polishing stone EkNk-3:47 recovered from Level 3, Unit B85.



Figure B3-6. Examples of shell recovered from EkNk-3. L to R: *Stagnicola caperata*, *Valvata tricarinata*, and *Gyraulus parvus*.

Appendix C

Soil Stratigraphy

This appendix presents details regarding the soil stratigraphy observed during excavations at EkNj-4 (Section C1), EkNj-68 (Section C2), and EkNk-3 (Section C3). It also includes plan view drawings for the hearths that were excavated at each of the sites.

C1. EkNj-4

The general stratigraphy of EkNj-4 is described in Section 5.1.2, summarized in Table C1-1, and illustrated in Figure C1-1, which shows stratigraphic profiles of excavated units J32 and J33.

Table C1-1. EkNj-4 Stratigraphic Levels

Strata	Munsell Colour	Composition	Inclusions	Remarks
Stratum I	10YR 2/2 very dark brown.	Organics and littermat.	Grasses, littlermat, roots.	Present in both excavated units.
Stratum IIa	10YR 2/1 black.	Loamy clay.	Roots, 10% sub-rounded gravel.	Present in both excavated units. This stratum denotes slickenside characteristics where vertic action has occurred, in some cases extending beyond the 30 cm maximum depth which was excavated. Cultural material recovered from these deposits.
Stratum IIb (Hearth Deposits)	10YR 2/1 black.	Loamy clay.	Occasional roots. Charcoal present.	Present in both excavated units. A roughly bowl shaped feature. Cultural material recovered from these deposits.
Stratum IIc	10YR 3/2 very dark greyish brown.	Silty clay.	10% sub-rounded and sub-angular gravel.	Present in both excavated units. Represents the majority of Stratum II, with the exception of the areas of vertic action (IIa) and hearth deposits (IIb). Cultural material recovered from these deposits.
Stratum III	10YR 4/2 dark greyish brown.	Clay.	10% sub-rounded and sub-angular gravel and a few large cobbles.	Only encountered in Unit J32. No cultural material present from these deposits.

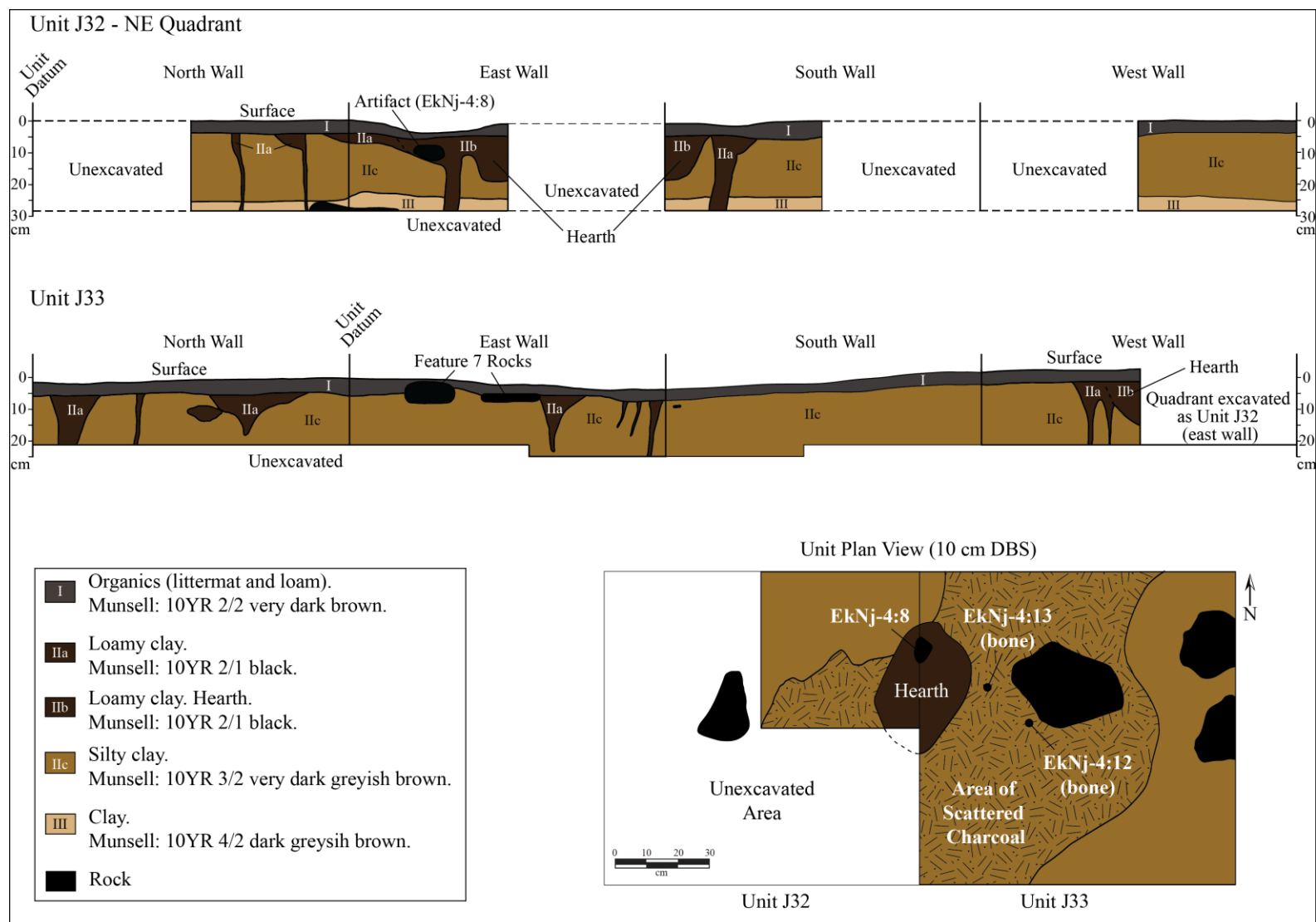


Figure C1-1. Stratigraphic profiles for units J32 and J33 at EkNj-4 and plan view of hearth.

C2. EkNj-68

The general stratigraphy of EkNj-68 is described in Section 5.2.2, summarized here in Table C2-1, and illustrated in Figure C2-1, which shows stratigraphic profiles of excavated units S65 and S75.

Table C2-1. EkNj-68 Stratigraphic Levels

Strata	Munsell Colour	Composition	Inclusions	Remarks
Stratum I	10YR 5/2 greyish brown.	Littermat and loamy clay.	Grasses, littlermat, roots.	Present in both excavated units.
Stratum IIa (Hearth Deposits)	10YR 2/1 black.	Loamy clay.	Occasional roots. Charcoal present.	Present in both excavated units. This stratum denotes hearth deposits - a poorly defined area of blackened soil with charcoal. Cultural material recovered from these deposits.
Stratum IIb	10YR 2/2 very dark brown.	Loamy clay.	Roots, 10% sub-rounded gravel.	Present in both excavated units. Cultural material recovered from these deposits.
Stratum III	10YR 4/4 dark yellowish brown.	Clay.	20% sub-rounded and sub-angular gravel.	Cultural material recovered at the interface between strata IIb and III.

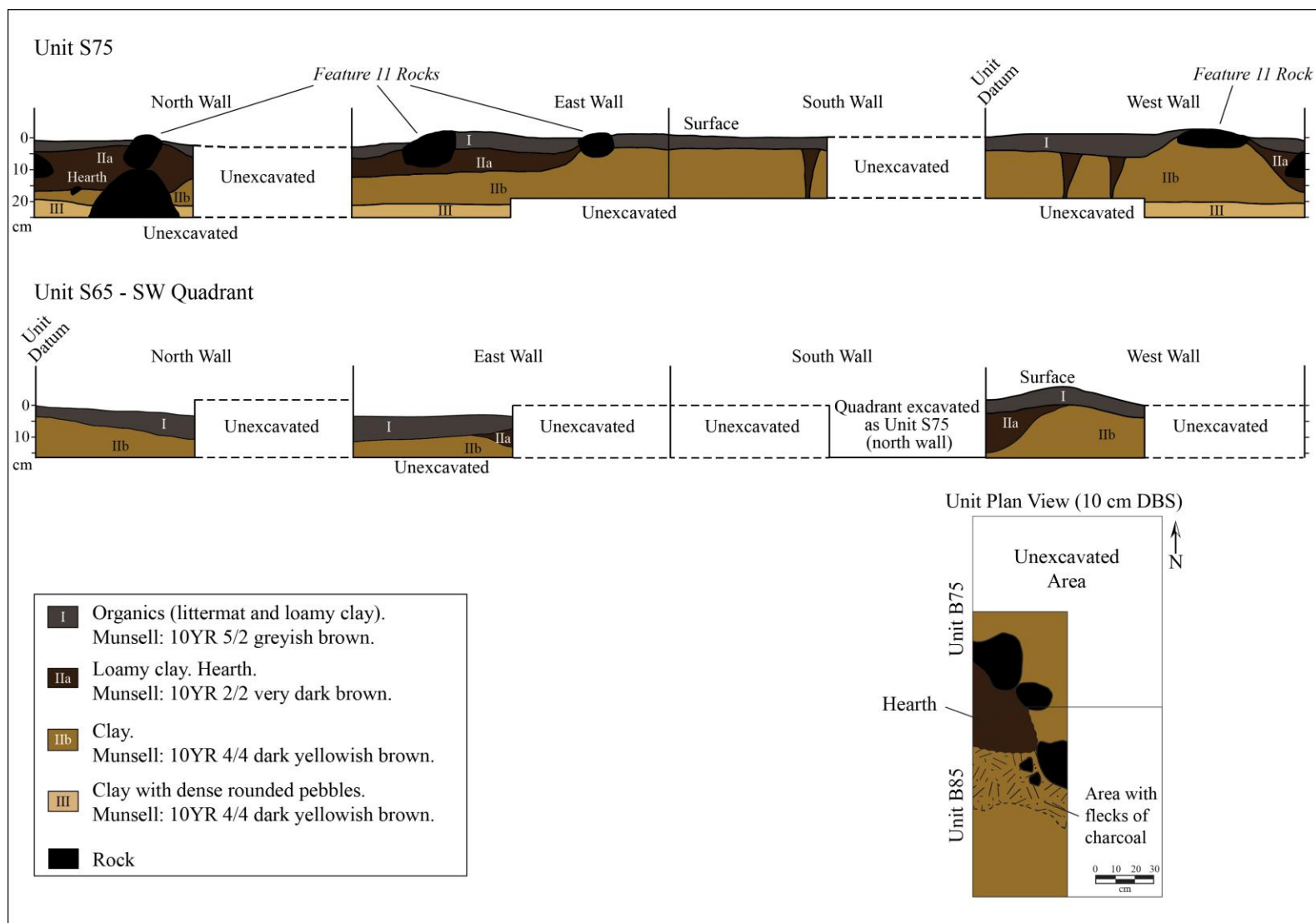


Figure C2-1. Stratigraphic profiles for units S65 and S75 at EkNj-68 and plan view of hearth.

C3. EkNk-3

The general stratigraphy of EkNk-3 is described in Section 5.3.2, summarized here in Table C3-1, and illustrated in Figure C3-1, which shows stratigraphic profiles of excavated units B75 and B85.

Table C3-1. EkNk-3 Stratigraphic Levels

Strata	Munsell Colour	Composition	Inclusions	Remarks
Stratum Ia	10YR 2/2 very dark brown.	Littermat and loam.	Grasses, littlermat, roots.	Present in both excavated units. Cultural material recovered from these deposits.
Stratum Ib				Present in both excavated units. This stratum denotes slickenside characteristics where vertic action has occurred, in some cases extending beyond the 30 cm maximum depth which was excavated. Cultural material recovered from these deposits.
Stratum IIa (Hearth Deposits)	10YR 4/4 dark yellowish brown	Clay.	Occasional roots. Charcoal, FBR, and burnt soil present.	Present in both excavated units. This stratum denotes hearth deposits - a roughly bowl shaped feature. Cultural material recovered from these deposits.
Stratum IIb	10YR 4/4 dark yellowish brown	Clay.	Occasional roots. Compact..	Present in both excavated units. Cultural material recovered from these deposits.
Stratum IIc	10YR 6/4 pale yellowish brown	Silty clay.	Fine snail shells. 5% sub-rounded gravel.	Present in both excavated units. Cultural material recovered at the interface between this stratum and those overlying it.
Stratum IId	10YR 8/2 very pale brown	Lens of sandy silt.	None.	Only observed in south wall of unit B75. No cultural materials recovered from these deposits.
Stratum III	10YR 7/1 light grey	Ashy silt.	None.	Present in both excavated units. This stratum denotes an ashy lens below the bowl-shaped hearth. Cultural material recovered from these deposits.
Stratum IV	10YR 6/3 pale brown	Silty clay.	Large boulders.	Present in both excavated unit. No cultural materials recovered from these deposits.

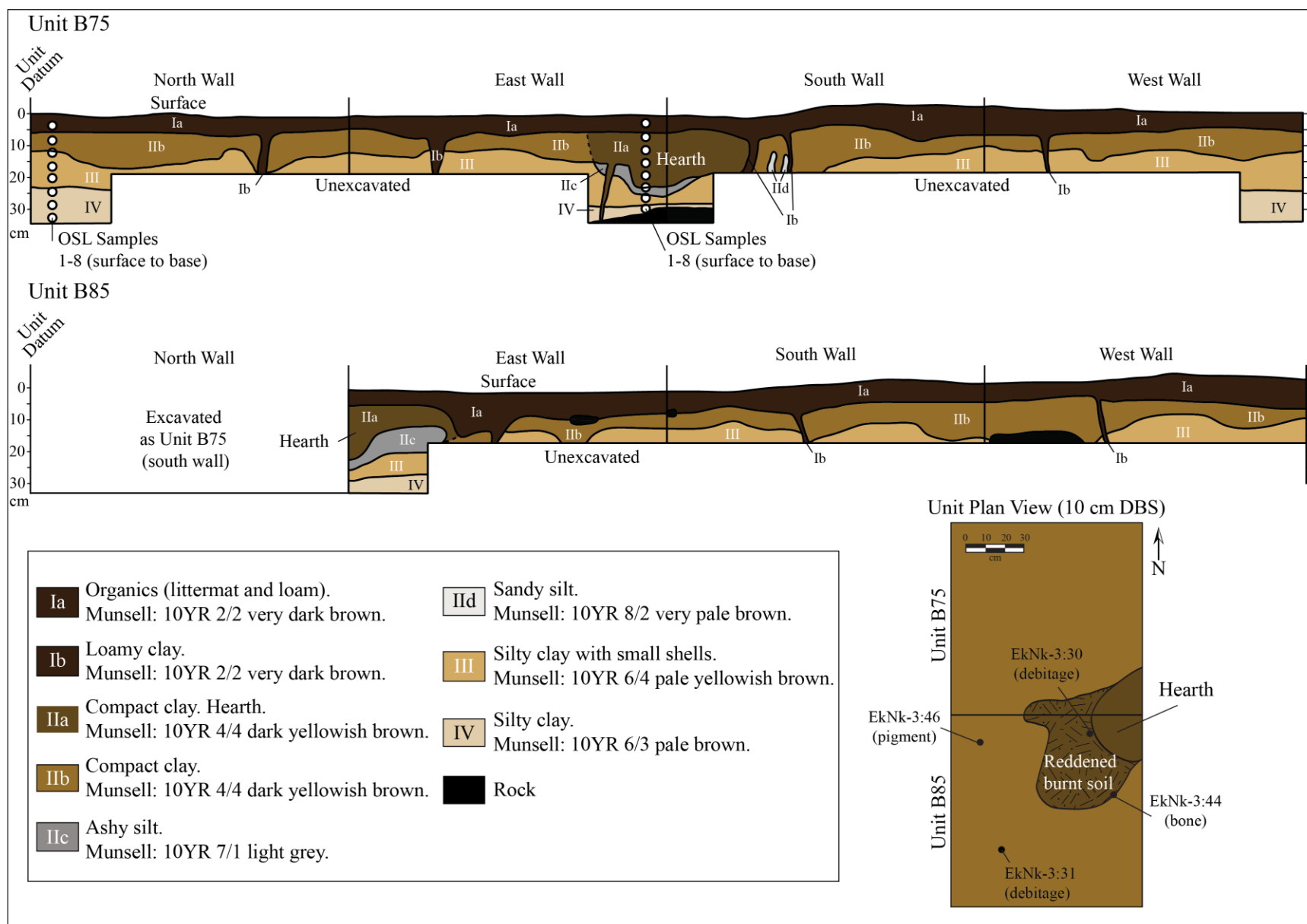


Figure C3-1. Stratigraphic profiles for units B75 and B85 at EkNk-3 and plan view of hearth.

Appendix D

Radiocarbon Analysis Results

This appendix presents the results of radiocarbon analyses carried out on charred organics recovered during excavations at EkNj-4, EkNj-68, and EkNk-3 by A.E. Lalonde AMS Laboratory at the University of Ottawa.



A.E. Lalonde AMS Laboratory, University of Ottawa
25 Templeton St., Ottawa, ON, K1N 6N5, Canada
Dr. W. E. Kieser, Director

613-562-5800 (7314)
www.ams.uottawa.ca
liam.kieser@uottawa.ca

April 21, 2016

Ms. Kay Jollymore
University of Saskatchewan
55 Campus Dr.
Saskatoon, SK
S7N 5B1

RE: Little Manitou Lake Archaeological Research Project

Dear Ms. Jollymore,

Please see below for radiocarbon analysis results for the four charcoal samples submitted in early March. All four samples were processed without issue, although the calibrated results fall a the flat section of the calibration curve. For more details, see the calibration paragraph on the “Seuss Effect”.

The preparators for your samples were Carley Crann and Sarah Murseli, and the AMS analyst was Dr. Xiao-Lei Zhao. If you have specific questions about the analyses or calibration, please direct them to ccrann@uottawa.ca. If this data is used in publication or for a graduate thesis, we would appreciate a copy of the abstract for our records. In the interest of future researchers, we encourage you to take the time to submit your radiocarbon results to either the Canadian Archaeological Radiocarbon Database (CARD), or to the Neotoma Paleoecology Database.

Thank you for choosing the André E. Lalonde AMS Laboratory. We look forward to working with you again.

Sincerely,

Dr. W. E. Kieser
Director, A. E. Lalonde AMS Laboratory
Associate Professor, Department of Physics



A.E. Lalonde AMS Laboratory, University of Ottawa
25 Templeton St., Ottawa, ON, K1N 6N5, Canada
Dr. W. E. Kieser, Director

613-562-5800 (7314)
www.ams.uottawa.ca
liam.kieser@uottawa.ca

June 17, 2016

Ms. Kay Jollymore
55 Campus Dr.
Dept. of Archaeology and Anthropology
Saskatoon, SK
S7N 5B1

RE: Radiocarbon analysis result, Little Manitou Lake Archaeological Research Project

Dear Ms. Jollymore,

We are pleased to provide a radiocarbon analysis result for the charcoal sample you had put on hold from the early March submission. There were no issues to report of.

The preparator for your samples was Carley Crann, and the AMS analyst was Dr. Xiao-Lei Zhao. If you have specific questions about the analyses or calibration, please direct them to ccrann@uottawa.ca. If this data is used in publication or for a graduate thesis, we would appreciate a copy of the abstract for our records. In the interest of future researchers, we encourage you to take the time to submit your radiocarbon results to either the Canadian Archaeological Radiocarbon Database (CARD), or to the Neotoma Paleoecology Database.

Thank you for choosing the André E. Lalonde AMS Laboratory. We look forward to working with you again.

Sincerely,

Dr. W. E. Kieser
Director, A. E. Lalonde AMS Laboratory
Associate Professor, Department of Physics

Reporting of Data

In this analysis report, we have followed the conventions recommended by Millard (2014).

Radiocarbon Analysis

Radiocarbon analyses were performed on a 3MV accelerator mass spectrometer (AMS) by High Voltage Engineering. Measurements were normalized with respect to the reference material Oxalic II ($F^{14}\text{C}=1.34$) and ages are calculated using the Libby ^{14}C half-life of 5568 years. The errors on ^{14}C ages represent 1σ confidence limits.

Calibration

Calibration was performed using OxCal v4.2.4 (Bronk Ramsey, 2009). Calibrated results are given as a range (or ranges) with an associated probability as point estimates (mean, median) cannot represent the uncertainties involved (Millard, 2014). We acknowledge that point estimates are often desired and are thus included on the calibration plots in the Appendix, but we recommend that data tables used in publication maintain calibrated age ranges.

Where the $F^{14}\text{C}$ is less than 1, the IntCal13 calibration curve was used for Northern Hemisphere samples and ShCal13 for Southern Hemisphere samples (Reimer et al., 2013).

For samples with an $F^{14}\text{C}$ greater than 1, the post-bomb atmospheric curve was used (Hua et al., 2013). Post-bomb samples have two age ranges due to calibration on both sides of the bomb pulse. There are methods for deciding which side of the bomb pulse to select as the more appropriate date so feel free to contact us for further information.

Samples that calibrate between the 1700's and early 1950's will always result in a calibrated age range covering the majority of this period. This is due to the "Seuss Effect", which is a flat portion of the calibration curve caused by the burning of fossil fuels.

Rounding

Calibrated ages and ranges are rounded to the nearest year which may be too precise in many instances. Users are advised to round results to the nearest 10 yr for samples with standard deviation in the radiocarbon age greater than 50 yr, but rounding should only be done at the final reporting stage as intermediate rounding may introduce errors (Millard, 2014).

Table 1. Radiocarbon results. Calibration was performed using OxCal v4.2.4 (Bronk Ramsey 2009)

Lab ID	Submitter ID	Material	Mat. Code ^a	¹⁴ C yr BP	±	F ¹⁴ C	±	Cal AD
UOC-1957	EkNj-4:C1	Charcoal	AAA	158	20	0.9805	0.0025	1667-1954 ^{b,c}
UOC-1958	EkNj-4:C2	Charcoal	AAA	160	19	0.9802	0.0023	1667-1954 ^{b,c}
UOC-1959	EkNj-68:C1	Charcoal	AAA	121	22	0.9851	0.0027	1681-1954 ^{b,c}
UOC-1960	EkNk-3:C10	Charcoal	AAA	Modern		1.0082	0.0027	1954-1956
UOC-2408	EkNk-3:C9	Charcoal	AAA	326	34	0.9602	0.0040	1472-1645 ^d

^a Please see below for definitions^b Post-bomb atmospheric NH1 curve (Hua et al. 2013) was used, although most samples are technically pre-nuclear weapons test.^c Seuss Effect^d IntCal13 (Reimer et al. 2013)

Material Codes

Graphite (G)

Graphite samples (on Fe powder) are submitted along with at least one process blank, one secondary standard, 6 oxalic II standards, and 6 Fe blanks. This formula is subject to change depending on the project. Clients are charged for the unknown samples only. Samples of graphite are submitted directly to target pressing and AMS measurement.

CO₂ (C)

Samples of pure CO₂ are submitted in 6 mm OD x 15 mm long Pyrex breakseals. The pCO₂ must be known and cannot exceed an equivalent 4 mgC. Breakseals are submitted directly to graphitization (details below).

Gas (CX)

Gas samples requiring purification to CO₂ are submitted in an air-tight glass bottle with septa. CO₂ is extracted from the gas sample by Helium carrier. The volume of the sample bottle is flushed minimum 10x at 200 ml/min and CO₂ is trapped cryogenically on a U-trap packed with Silver wool. After the extraction period, the Helium flow is cut off and the sample is transferred to a vacuum line for cryogenic purification with a -80°C ethanol slurry to remove water and other non-condensable gases. The CO₂ is then transferred to a 6 mm OD Pyrex breakseal containing a few grains of silver cobaltous (previously baked at 500°C for two hours). The sealed breakseal is baked overnight at 200°C so any sulfur is removed by the silver cobaltous (Palstra & Meijer, 2014).

Direct Combustion (D)

When previously determined that pretreatment is not required, samples may be submitted for direct combustion. Ideally, samples are received dry, either dried by freeze drier or by oven at 60°C overnight. Samples are weighed into a tin capsule and combusted using a Thermo Flash 1112 elemental analyzer in CN mode interfaced with an extraction line to trap the pure CO₂ in a pre-baked 6 mm pyrex tube.

Acid – Alkali – Acid (AAA)

The standard AAA pretreatment at the Lalonde AMS Laboratory follows the protocol outlined in Brock et al. (2010). Briefly, sedimentary or other carbonates are removed during the first acid wash (HCl, 1N, 80°C, 30 mins), humic acid is removed during one or more alkali washes (NaOH, 0.2N, 80°C, 30 mins), and any CO₂ absorbed during the alkali step is removed with a second acid wash (HCl, 1N, 80°C, 30 mins). Each step is followed by three rinses in MilliQTM water. Clean samples are freeze dried overnight before combustion (see D).

Acid Only (A)

If humic acid is not believed to be an issue, or the submitter does not wish for it to be removed, the sample will follow the AAA pretreatment protocol, omitting the alkali step and second acid wash.

Cellulose Extraction for Wood (AAAB)

The cellulose extraction for wood at the Lalonde AMS Laboratory follows the protocol outlined in Staff et al. (2014). Briefly, the standard AAA pretreatment (Brock et al., 2010) is followed by a bleach treatment at 80°C. The samples are monitored and removed once the colour has turned white. After three rinses in MilliQTM water, the samples are freeze dried overnight before combustion (see D).

Humic Acid (HA), Humin (H)

The humic acid and humin fractions are extracted using a slightly modified version of the standard acid-base-acid procedure found in Lowe et al. 2004. Samples are heated at 80°C for 30 mins with 0.5M HCL to remove carbonates and then rinsed three times with Milli-Q water to remove acid. To extract humic acid, 2M KOH is added and samples are heated at 80°C for 24 hours. After 24 hours the samples are centrifuged and the supernatant, containing humic acid, is decanted and saved. The KOH procedure is performed a second time to further release humic acid. The humic fraction is then then filtered through a baked glass fiber filter to remove particulates, precipitated with concentrated HCl, centrifuged, decanted, rinsed to neutral with Milli-Q water, and freeze dried. The humin fraction is centrifuged and rinsed to neutral pH with Milli-Q water and then freeze-dried.

Collagen Extraction (B)

Following Brock et al. (2010), the sample is first decalcified with 0.5N hydrochloric acid (3 or 4 rinses over ~18 hr, room temperature), treated with 0.1N sodium hydroxide to remove humic acid (30 min, room temperature), and 0.5N HCl again (30 mins, room temperature) to remove any CO₂ that may have been absorbed during the base wash. Each step is followed by three rinses with MilliQTM water. The samples are gelatinized at 60°C (Beaumont et al., 2010) overnight at pH 3 and filtered using a cleaned glass WhatmanTM autovial syringeless filter. The filtrate is freeze dried overnight and the resulting collagen combustion (see D).

Ultrafiltration (BU)

Ultrafilters (VivaspinTM 30 kDa MWCO) are first cleaned by centrifuging with MilliQ two times, 15 mins of ultrasonic cleaning in MilliQ, then centrifuged again three times with MilliQ (Bronk Ramsey et al., 2004). The sample, following the filtration step of the collagen extraction (B), is centrifuged in the ultrafilter and the >30 kDa fraction is removed and freeze dried before combustion (see D).

Carbon and Nitrogen Stable Isotopes

After sampling for radiocarbon dating, the extracted collagen is submitted to the GG Hatch Stable Isotope Laboratory (University of Ottawa) for carbon and nitrogen stable isotope analysis by isotope ratio mass spectrometry (IRMS, Delta Advantage).

Skin, Parchment, Leather, Hide (X)

To remove lipids and potential conservation treatments, samples are first subjected to a solvent wash as follows (Brock 2013): hexane (45°C, 1hr); acetone (45°C, minimum 1hr); 2 x 1:1

methanol:chloroform (room temperature, 1hr each). Samples are then left to air-dry overnight or longer to ensure complete removal of solvents before the subsequent AAA pretreatment. Sedimentary or other carbonates are removed during the first acid wash (HCl, 0.5N, 20°C, 30 mins), humic acid is removed during one or more alkali washes (NaOH, 0.2N, 20°C, 30 mins), and any CO₂ absorbed during the alkali step is removed with a second acid wash (HCl, 0.5N, 20°C, 30 mins). Each step is followed by three rinses in MilliQTM water. The samples are then freeze dried overnight and combusted (see D).

Carbonate CO₂ Extraction with a pre-etch (S) or without pre-etch (SN)

Carbonate samples are manually cleaned (if necessary), and pre-etched with weak HCl to remove the outer 20%. For small samples (e.g. forams) or powders (e.g. SrCO₃) no pre-etch is necessary. The samples are added to pre-baked, two-arm glass reaction vessels and concentrated H₃PO₄ (3 mL, 100%) is added to the shorter arm. The vessel is evacuated, the valve closed, the vessel tipped, and the sample left to react overnight. The CO₂ is extracted and cryogenically purified before being sealed in a 6 mm pre-baked PyrexTM breakseal.

Particulate Organic Carbon (POC)

Samples for radiocarbon analysis of POC are typically submitted on precombusted WhatmanTM GF/C filters (1.2 µm). The filters are acid fumigated with 12N HCl to remove inorganic carbon and dried overnight at 60°C. Half of each filter is combusted in a tin capsule using a Thermo Flash 1112 elemental analyzer in CN mode interfaced with an extraction line to trap the pure CO₂ in a pre-baked 6 mm pyrex tube. The second half is reserved for a duplicate if needed.

Dissolved Inorganic Carbon (DIC) and Dissolved Organic Carbon (DOC)

For DIC extraction, 85% phosphoric acid is added to the bottle, heated to 60°C and left overnight, and the headspace is sparged with helium. The gas is then cryogenically purified, and either trapped in a 6 mm breakseal for analysis or discarded if only DOC is desired. For the DOC extraction, sodium persulfate is added, the vessel is heated to 99°C for 30 minutes, the head space is sparged with helium, and the gas is purified in a vacuum line to produce pure CO₂, which is trapped in a pre-baked 6 mm pyrex tube.

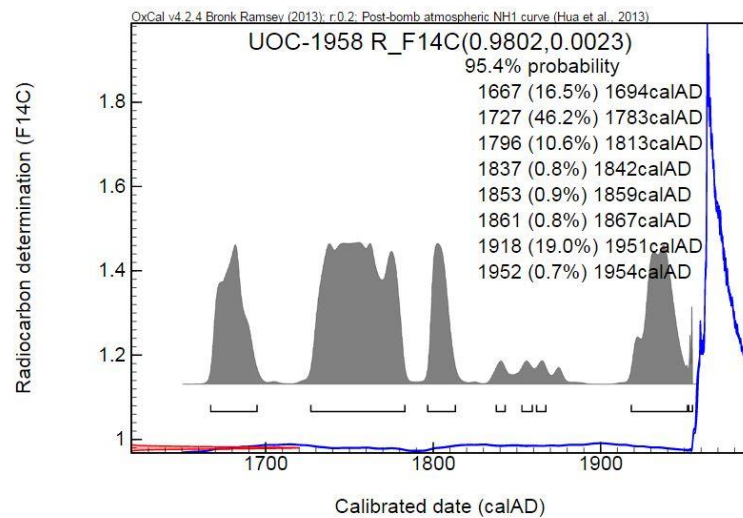
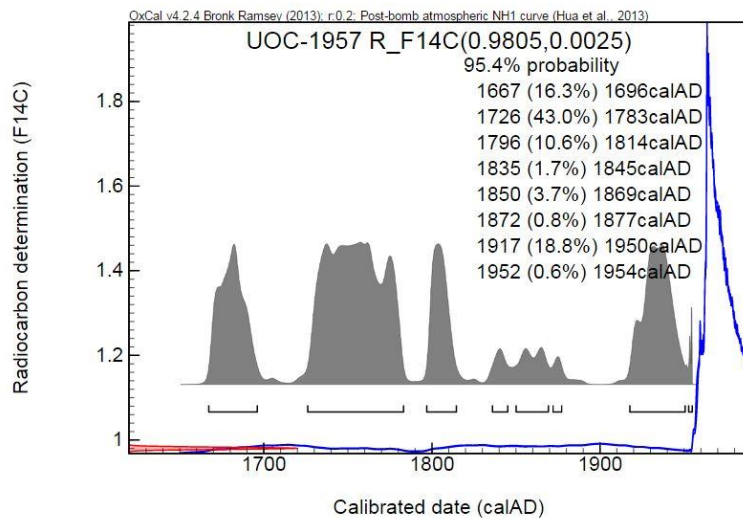
Graphitization

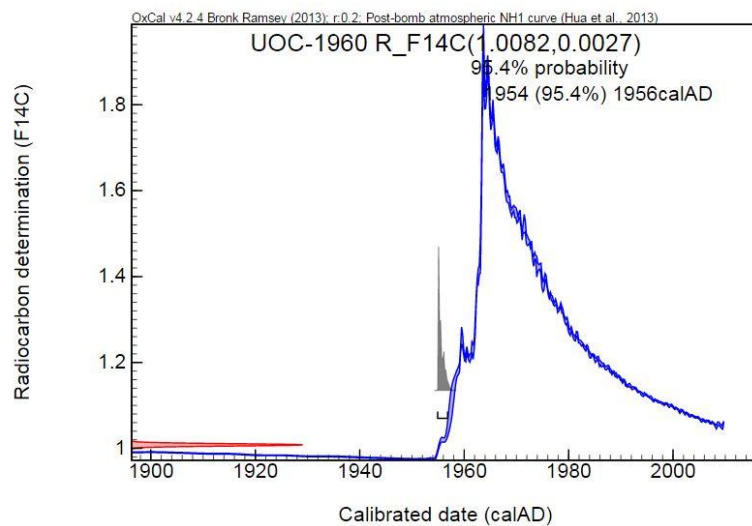
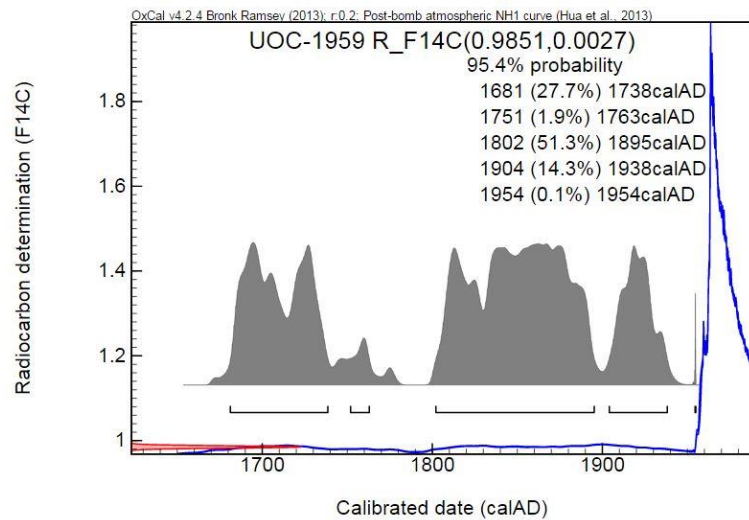
Samples of pure CO₂ in 6 mm breakseals were converted to elemental carbon in the presence of hydrogen using the semi-automated graphitization lines which were designed and built in-house at the Lalonde AMS Laboratory.

References

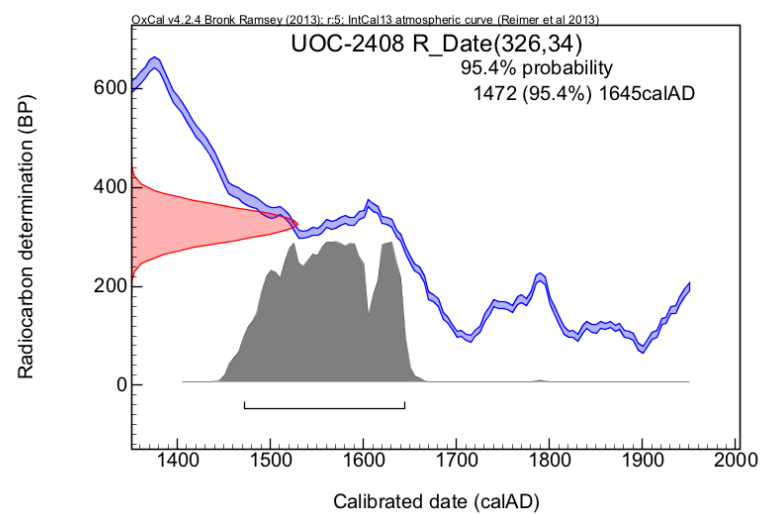
- Beaumont, W., Beverly, R., Southon, J., Taylor, R.E., 2010. Bone preparation at the KCCAMS laboratory. *Nuclear Instruments and Methods in Physics Research B* 268, 906-909.
- Brock, F. 2013. Radiocarbon dating of historical parchments. *Radiocarbon* 55(2-3), 353-363.
- Brock, F., Higham, T., Ditchfield, P., Bronk Ramsey, C., 2010. Current pretreatment methods for AMS radiocarbon dating at the Oxford Radiocarbon Accelerator Unit (ORAU). *Radiocarbon* 52(1), 103-112.
- Bronk Ramsey, C., 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51, 337-360.
- Hua, Q., Barbetti, M., Rakowski, A.Z., 2013. Atmospheric radiocarbon for the period 1950-2010. *Radiocarbon* 55(4), 2059-2072.
- Lowe, J.J., Walker, M.J.C., Scott, E.M., Harkness, D.D., Bryant, C.L., Davies, S.M., 2004. A coherent high-precision radiocarbon chronology for the Late-glacial sequence at Sluggan Bog, Co. Antrim, Northern Ireland. *Journal of Quaternary Science* 19(2), 147-158.
- Millard, A., 2014. Conventions for reporting radiocarbon determinations. *Radiocarbon* 56(2), 555-559.
- Palstra and Meijer, 2014. Biogenic Carbon Fraction of Biogas and Natural Gas Fuel Mixtures Determined with ^{14}C . *Radiocarbon*. 56, 1, p. 7-28 22 p.
- Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey, C., Buck, C.E., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., van der Plicht, J., 2013. IntCal13 and MARINE13 radiocarbon age calibration curves 0-50000 years calBP. *Radiocarbon* 55(4), 1869-1887.
- Staff, R.A., Reynard, L., Brock, F., Bronk Ramsey, C., 2014. Wood pretreatment protocols and measurement of tree-ring standards at the Oxford Radiocarbon Accelerator Unit (ORAU). *Radiocarbon* 56(2), 709-715.

Appendix – Calibration plots





Appendix – Calibration plots



Appendix E

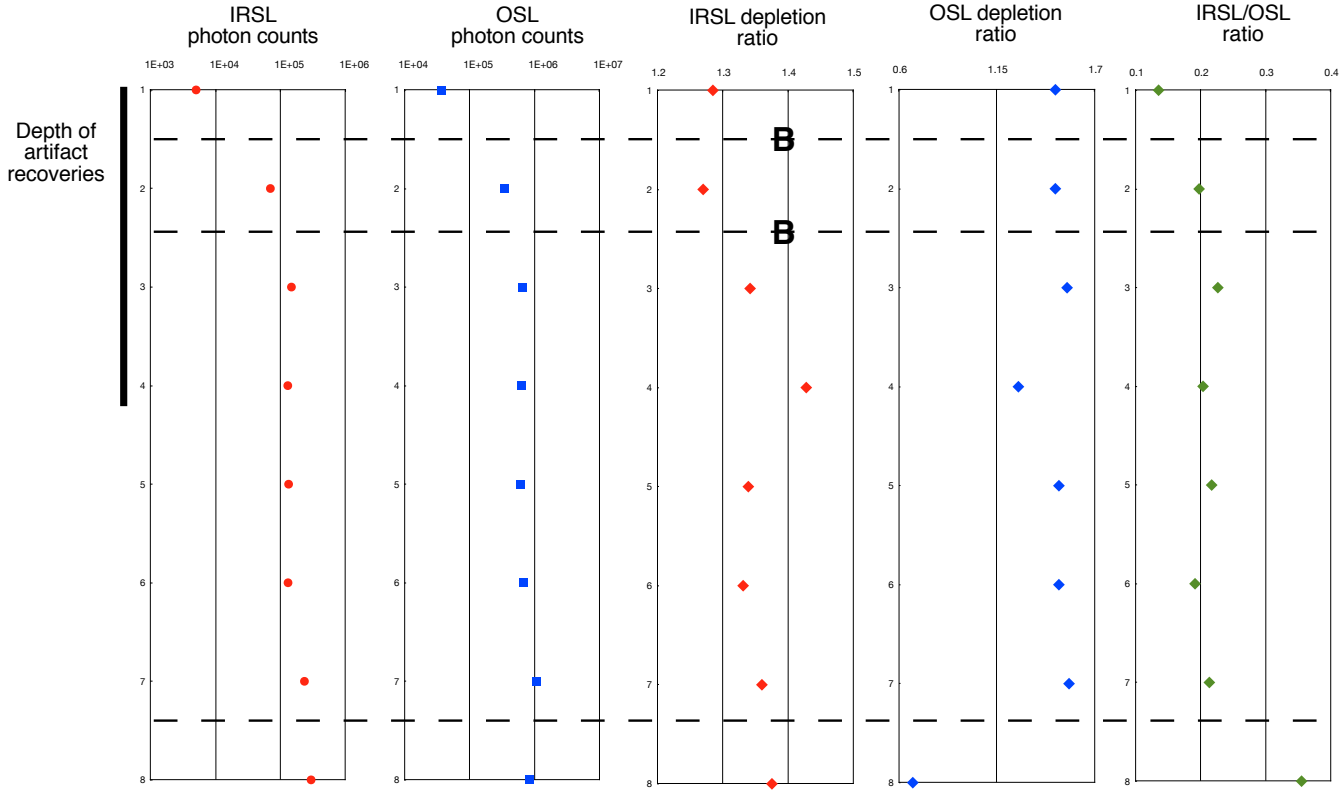
Portable Optically Stimulated Luminescence Results

This appendix presents the results of portable optically stimulated luminescence analyses carried out by Krista Gillaland of Western Heritage Consultants on soil samples collected from EkNk-3. The reader is referred to Appendix C3 for sampling locations.

EkNk-3 B75 East wall profile (hearth)

POSL Analysis

Interpretation



Gradual deposition in upper portion of the stratigraphy

Photon counts suggest depositional breaks (B) or very slow deposition from Samples 3 to 1-suggests site may represent multiple occupations

OSL depletion ratio suggests that Samples 3 to 1 may have similar depositional history

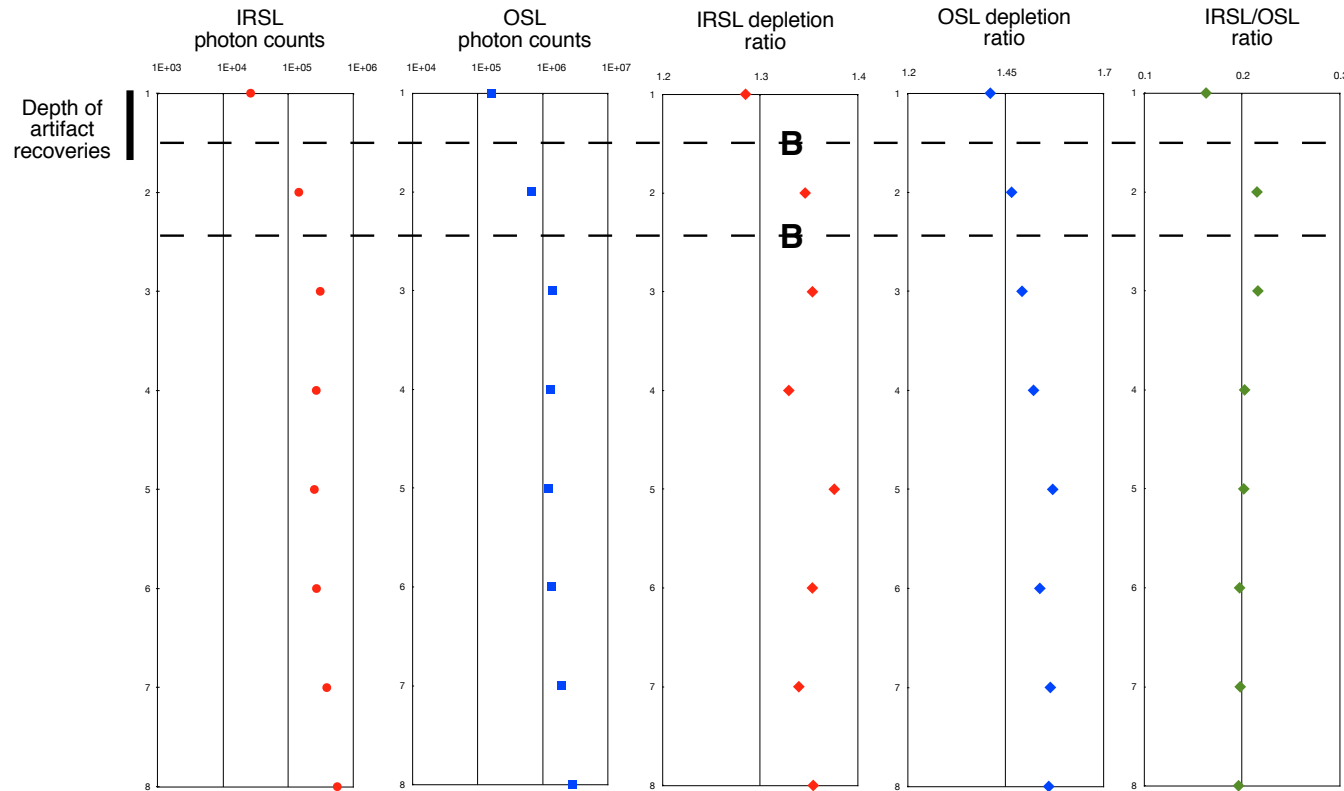
IRSL/OSL ratio indicates similar mineralogy of sampled sediments overall, with Sample 8 possibly the exception

More gradual deposition in Samples 8 and 7 than for overlying Samples 6 to 3, which appear to have been rapidly deposited

EkNk-3 B75 North wall profile

POSL Analysis

Interpretation



Gradual deposition in upper portion of the stratigraphy

Photon counts suggest depositional breaks (B) or very slow deposition from Samples 3 to 1

IRSL/OSL ratio supports the interpretation from East wall POSL that Samples 3 to 1 may be more similar to each other than to the other samples in the set

IRSL/OSL ratio indicates similar mineralogy of sampled sediments overall

More gradual deposition in Samples 8 and 7 than for overlying Samples 6 to 3, which appear to have been rapidly deposited